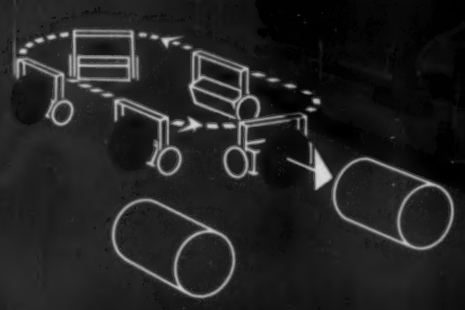
AUTOMATION

DECEMBER 1960



Making Power Circuit Breakers

THE MAGAZINE OF AUTOMATIC MANUFACTURING OPERATIONS

- Evaluating Project Economics
- Tape Control Sparks Process Revision
- Joining with Adhesives
- Doing the Job with Photoelectrics

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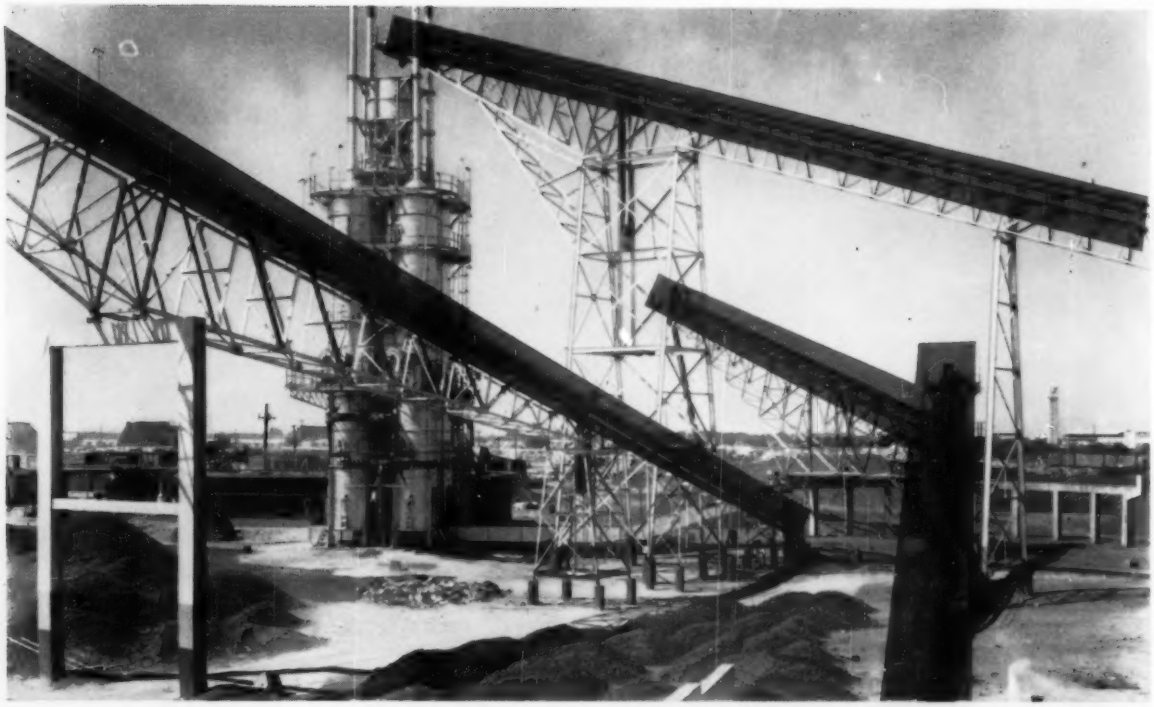
A PENTON PUBLICATION



Rotating stacker belt

PLANET SYSTEM CONVEYS, SORTS AND STORES 150 TONS OF IRON ORE PER HOUR . . .

another example of Planet Versatility . . .

Near Monterrey, Mexico, stands the maze of conveyors partially shown above. This system's job is to convey 150 tons of iron ore per hour through crushing operations to segregated storage areas, then reclaim it by grade. And it is one of many examples of PV—*Planet Versatility* . . . Planet Corporation's ability to find efficient solutions to production, materials handling or automation problems, big or small.

From a pit where the ore is crushed, a 24-inch trough-belt conveyor carries it to a secondary crusher. Here the rock is reduced and screened. Chunks larger than 1-inch diameter are recirculated, the fines are separated and transferred to a special stacker, and the usable ore is conveyed to a rotating stacker belt which piles it according to grade. To reclaim the ore, Planet constructed a series of tunnels under the storage area. The tunnels allow selection of the grade of ore to be conveyed to the retort in which sponge iron is made.

Let Planet demonstrate how its versatile engineering skill and production and erection know-how can solve your handling problems. Call or write . . . you'll find *it pays to plan with Planet.*

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1810 SUNSET AVENUE • LANSING, MICHIGAN

- Engineered Handling Systems
- Automation Equipment
- Mill & Foundry Handling Equipment

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Circle 651 on Page 19

As these scale models show, Heald's new line of standard "building-block" units can be combined in virtually any desired arrangement for single or multiple station automated production equipment. Slide units and Borizers can approach the work vertically, horizontally or at an angle, to perform any desired drilling, boring, reaming, tapping, probing, facing or grooving operations within their range and capacity.

The flexibility of these standard units provides maximum versatility in meeting your specific automation requirements—simplifies even major job changeovers by facilitating retooling, removal, relocation or addition of work stations—and safeguards your investment by substantially reducing losses from obsolescence.

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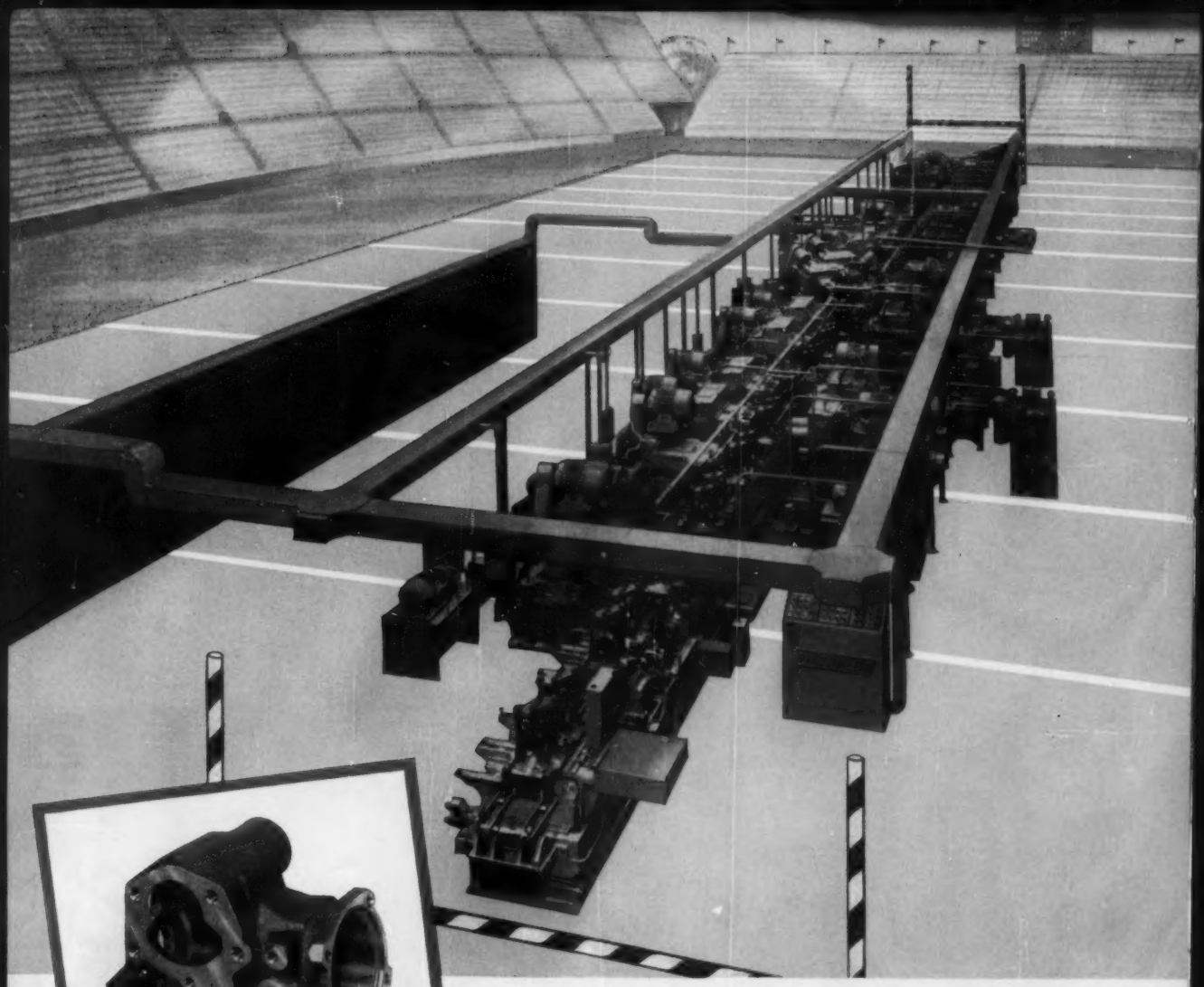

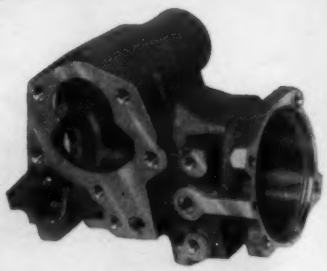

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"MACHINES DESIGNED WITH THE FUTURE IN MIND"

300 FEET LONG . . .

completely set up and tested before shipment

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Ed: This looks good to me - let's discuss it - JB.

The Magazine of Automatic Manufacturing Operations

DECEMBER 1960
Vol. 7—No. 12

AUTOMATION

A PENTON PUBLICATION

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automation outlook

COMPARING RETURNS AND COST OF CAPITAL

". . . Any firm's cost of funds, commonly called its cost of capital, represents a minimum return figure below which no investment projects should be accepted. It is evident that the method of computing the rate of return for an investment project must produce a figure that is directly comparable with the cost-of-capital figures. . . ."—*T. C. Stout, staff member, Arthur D. Little Inc., and J. W. Weber, staff member, McKinsey & Co. Inc.,* *see page 46.*

INTEGRATED ISLANDS OF AUTOMATION

". . . Today, we are on the threshold of Integrated Automation. The islands of automation can now be tied together into an integrated system including business and process information handling, process control and material handling. . . ."—*H. A Strickland Jr., vice-president and general manager, Industrial Electronics Div., General Electric Co.*

GROWTH AREA FOR MATERIALS HANDLING

". . . we have tended to regard distribution as some sort of sideline of manufacturing, when in fact it requires its own technology. Here then is the next big growth area for materials handling. Perhaps our biggest single frontier for cost savings. . . ."—*R. L. Speaker, president, Speaker Sortation Systems Inc.*

IT'S IN THE MACHINERY

". . . The rate of production of modern machine tools is being designed into the machine itself. Completely automatic machines work at a steady pace throughout the day and integration of such machines into a production line assure a steady, coordinated flow of work through a modern high production manufacturing plant . . . ."—***E. M. Hicks, vice president and general manager, Machine Tool Div., Norton Co.***

USSR CONSTRUCTION AUTOMATED

". . . largest single activity in the Soviet Union is construction, as a result of the basic political decision to transform the country from an agricultural to an industrial economy. To accomplish the ends desired, it is necessary that this construction be fully industrialized; thus, practically all building is carried out as an automatic factory operation. . . ."—*A. A. Bates, vice president of research and development, Portland Cement Association.*

ADVANCING CONTROL TECHNOLOGY

". . . Strong forces are pushing toward a form of automation that goes beyond the popular control loops of today. This new form—process computers—will have decision-making capabilities. . . . the basic reasons for installing a computer are economic—increasing profits, increasing throughput, improving quality and improving production flexibility, among other things. . . ."—***K. R. Knoblauch, chemical industry market manager, Brown Instruments Div., Minneapolis-Honeywell Regulator Co.***

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Penton Building, Cleveland 13, Ohio
Main 1-8260

ROGER W. BOLZ
Publisher-Editor

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BPA NBP

... Fluid Power news

REPORT NO. 12,106 NEW PAPER MACHINE SECTIONS OILGEAR CONTROLLED

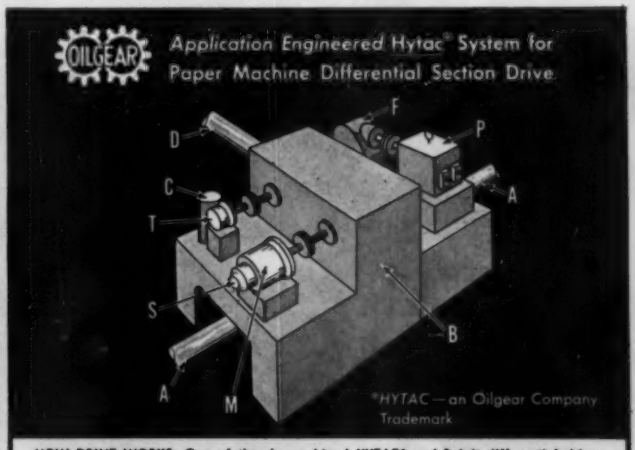
From Oilgear Application-Engineering Files

HOW *HYTAC** SYSTEMS PRECISELY CONTROL SECTION SPEEDS OF VERSATILE NEW PAPER MACHINE

BUILDER: *Paper Machine and Differential Drives — Beloit Iron Works, Beloit, Wis.*

DATA: Systems to individually vary and precisely control speed and draw on six sections of a new, versatile, 192-in., 90-ton capacity, Beloit fourdrinier paper machine designed to produce a variety of finished stock ranging from 33-lb toweling up to 190-lb food board. For 200- to 2000-fpm production operation—a range not previously considered practical—main lineshaft speed to be adjustable over this 10:1 range. Beloit mechanical differentials to be used at each section. **REQUIREMENTS:** 1. Precise speed and draw control for each section—infinitely variable up to 10% under main lineshaft rpm—from simple, remote, push-button control panels. 2. Maintain each selected section speed within ±0.25% max. variation over a 50% load change at max. lineshaft speed. 3. Must be compact; frugal on electrical power input; insure trouble-free, continuous, heavy-duty, full-production paper machine drive service, and still provide maximum adaptability for short runs. 4. Be impervious to high humidity and high-pressure wash-downs. 5. One reputable source and responsibilty for these speed and draw control systems preferred.

Drive side of this versatile, new paper machine. "... to give perfect draw and speed control over an unprecedented wide range" ... six Beloit differential drives incorporate *HYTAC** *Systems*—indicated by arrows. This machine consumes approx. 39,000 tons of pulp per year in the production of grades ranging from 33-lb bleached and unbleached toweling to 190-lb coated or calendered food board.



HOW DRIVE WORKS: One of the six combined *HYTAC** and Beloit differential drives is shown schematically above. The turbine-drive lineshaft (A) drives all Beloit Mechanical Differentials (B). Controlled *Fluid Power* is delivered by Oilgear Variable Displacement Pump (P) driven by Differential (B) through Speed Increaser (F). *Fluid Power* from Pump (P) drives an Oilgear Constant Displacement Motor (M) to decrease speed of Section Drive Shaft (D). Oilgear Variable Displacement Master Tachometer (T) driven by Differential (B), and controlled remotely by electric Pilot Motor (C) delivers controlled low-pressure fluid to Oilgear Constant Displacement Slave Tachometer (S)—directly connected to Motor (M). Fluid in branch line from tachometer system operates hydraulic control on Pump (P). Operator can infinitely decrease rpm of Section Drive Shaft (D) up to 12% under lineshaft rpm—over entire 10:1 lineshaft range—by local or remote pushbutton stations connected to Pilot Motor (C) on Master Tachometer (T). Changing volume and/or direction of flow in tachometer system accurately changes volume and/or direction of fluid flow from Pump (P) to Motor (M). When main lineshaft rpm is increased or decreased, *HYTAC** System automatically, precisely synchronizes Driveshaft (D) rpm. All factors such as changes in load or temperature are automatically compensated for by these *HYTAC** Systems to maintain exact, set degree of section synchronization at all times.

SOLUTION: Application-Engineered *HYTAC** controlled differential drives provide precise, individual speed control on each of the following six sections of this new paper machine—20-hp Oilgear *Any-Speed* Drives on size press, 4th dryer, winder reel; 35-hp drives on 3rd dryer, 1st calender, 2nd calender. A typical *HYTAC** and Beloit differential section drive and its components are shown schematically, right.

These systems maintain any selected, individual section speed with less than ±0.25% variation regardless of load change over the entire 10:1 range of lineshaft speed . . . plus enabling operators to infinitely vary each section's drive rpm independently up to 12% under main lineshaft rpm.

A special slack take-up feature facilitates rapid change-over on short runs. This "Oilgear-Plus" feature operates from a momentary, over-ride, control panel pushbutton to rapidly take any one or all sections from threading speed to the desired production speed. Other "Oilgear-Plus" features are: 1. Cushioned, controlled starting, accelerations, deceleration, braking. 2. Positive, automatic overload protection. 3. Constant pressure and flood lubrication with continuous power fluid filtration. 4. A heavy-duty, long-lived, trouble-free, efficient, *sealed system*—impervious to high humidity and washdowns. 5. Complete freedom from maintenance-provoking belts, chains, or relays.

Circle 656 on Page 19

These Oilgear-Beloit Systems enable operators to equalize draw between sections, to increase draw or slack at specific sections, and to prevent overload on one or more sections.

They have met or exceeded all originally specified requirements. In this age of special, single-purpose machines, this new paper machine is unique in its versatility—being fully capable of long runs, it is, however, particularly adapted and used for short runs — competitively producing the many different types, weights, and finishes of stock. • . . . In addition, an 800-ton *Washington Iron Works* pulp baling press, and a *MURCO Wood Splitter* in this mill are also equipped with *Oilgear Application-Engineered Fluid Power Systems.*

For similar practical solutions to YOUR linear or rotary Controlled Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

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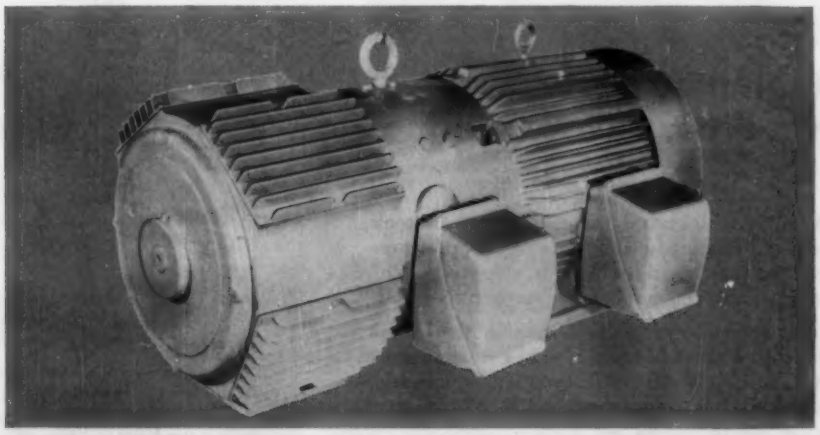
Mr. Westinghouse* and RectiFlow Drive maintain uniform output and work part finish of high production grinding machines built by Landis Tool Company

Landis Tool requires a constant horsepower self-regulated drive on some high production grinders. The Man from Westinghouse had exactly the right answer from among the world's widest line of adjustable speed drives.

RectiFlow† a-c adjustable speed drives with inherent constant horsepower assure constant peripheral speed of the grinding wheel for high cutting efficiency. This means that as the wheel diameter diminishes with wear, the speed of rotation is automatically increased assuring uniform precision, finish, number of pieces per hour, and longer useful wheel life. Two-bearing construction and precision dynamic balance assure high-quality finish of processed parts. These benefits sparked widespread use of RectiFlow Drives in the automotive industry.

RectiFlow "packaged" drives are outstanding where simplicity, static control and speed ranges up to 3 to 1 are required. Mr. Westinghouse has all details on where and how they—and other Westinghouse drives—can go to work for you. Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa. You can be sure . . . if it's Westinghouse.

**Art Greenfield, Westinghouse Sales Engineer in York, Pennsylvania.*



Easy-to-install RectiFlow Drives come in totally enclosed (above) and drip-proof designs for test stands, pumps, presses, machine tool drives, extruding machines, lathes and adjustable frequency synthetic fiber systems. J-22167

†Trade-Mark

Westinghouse

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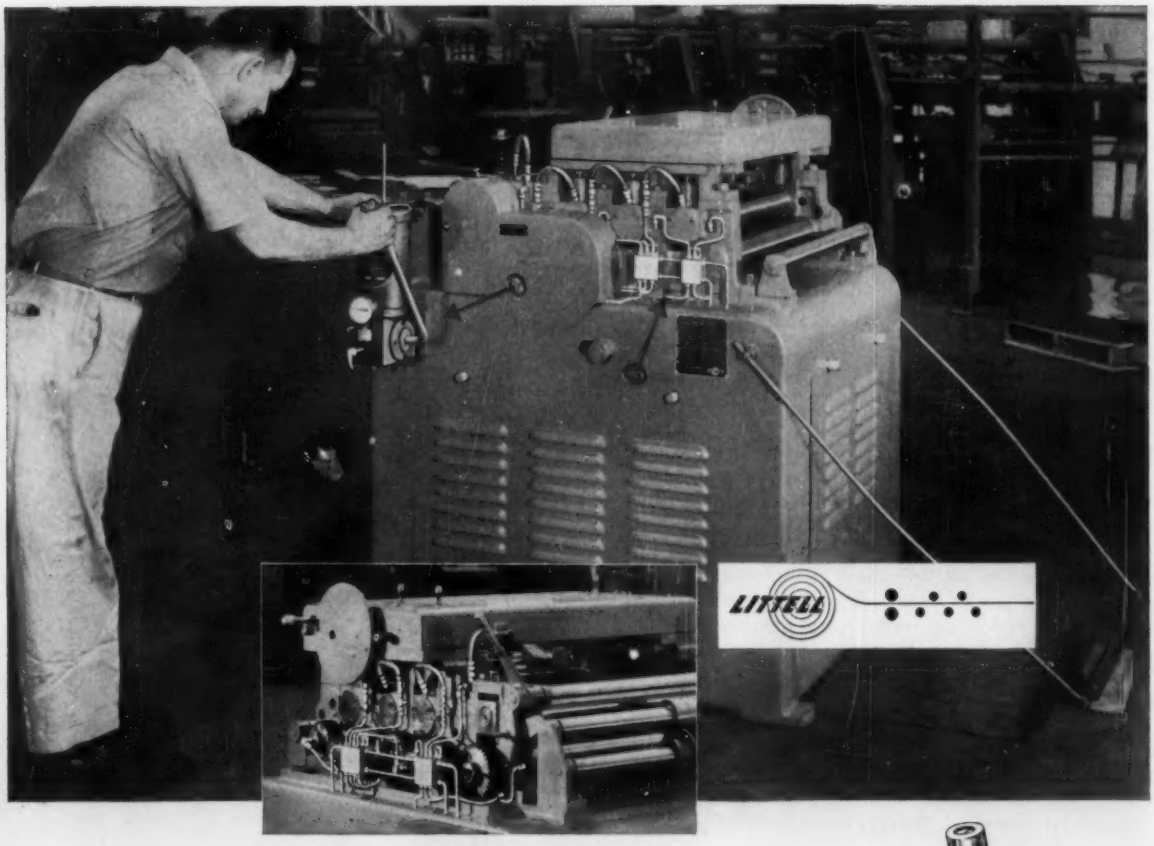

Farval Centralized Lubrication on Littell Straightening Machine Eliminates Down-time, Saves Bearings

This versatile No. 424 Littell Machine straightens coiled steel stock .050" thick by 24" wide, and automatically supplies a free loop of pre-straightened stock at proper speeds required for smooth, efficient punch-press operation—even through the most complicated progressive dies.

Keeping press output at top level allows no down-time for the Littell No. 424 straightener. Its built-in Farval Manual Dualine System protects the machine's 24 most important bearings—keeps them adequately lubricated while the machine remains continuously on the job.

On industrial equipment all over the world, Farval delivers measured amounts of clean lubricant at regular intervals to all vital bearings. From a central station, lubricant is pumped under pressure to a measuring valve at each bearing, providing the exact amount of lubricant desired.

If you want your production equipment to stay in top-operating condition—to reduce costs, boost profits—then write for free Bulletin 26-T. It tells the complete "Farval Story".

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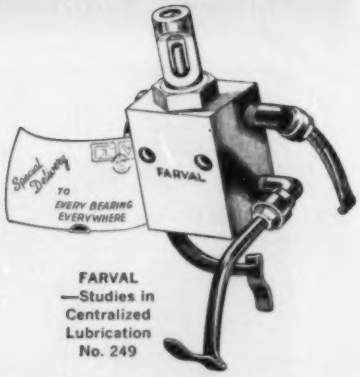
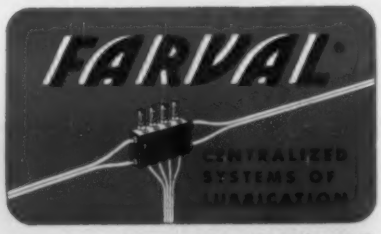


FARVAL
—Studies in Centralized Lubrication
No. 249

KEYS TO ADEQUATE LUBRICATION

—wherever you see the sign of Farval —the familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated. Farval manually operated and automatic systems protect millions of industrial bearings.



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AUTOMATION news

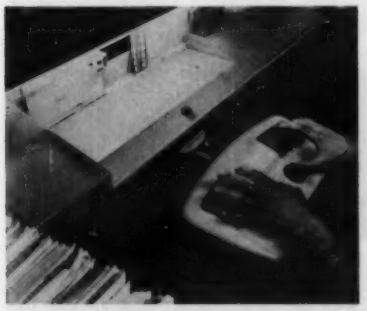
Today's events and developments in the field of automation

Equipment Developments Spur Post Office Automation

INCREASING volume of mail, which now totals 65 billion pieces annually, has caused the U. S. Post Office Dept. to continually seek ways to expedite mail through major post offices. Two recent developments promise to reduce costs and improve service in the letter-handling phase of Post Office activities.

A letter sorting machine, developed by Pitney-Bowes Inc., has been installed in the Washington, D. C., City Post Office. Adaptable to mail coding and electronic reading systems, the machine will have an ultimate capacity for sorting 60,000 letters an hour to 300 destination boxes. At the present time, input to the 75-foot long machine is directed from 12 consoles operated by trained personnel at special keyboards. Each console operator can sort 60 letters per minute.

Each console includes a *Start* and *Stop* control, a reject device, and a piece counter. By means of the controls, an operator at a console can position letters, one-at-a-time, in a display area. Upon reading an address, the operator depresses keys on a keyboard to route the letter to the proper destination box. Defective pieces can be rejected automatically.



CLOSE-UP of one of 12 console stations for letter sorting machine illustrates keyboard for routing letters automatically to any of 300 destination boxes. Operator reads address on envelope and depresses appropriate keys. Output of each station is approximately 60 letters per minute.

At the output end of the machine, letters are removed from the boxes by hand. Boxes are arranged in three levels for convenient emptying, and the quantity of mail in each box is visible at a glance.

A second development, under a prime contract with Intelex Systems Inc., a subsidiary of International Telephone and Telegraph Corp., involves equipment for high speed facsimile transmission of mail. With the system, letters may be scanned electronically and impulses sent by standard communications channels. At a designated receiving location, an exact reproduction of the original letter may be made on a printer. Output of the system is 15 letters per minute, and privacy of the mails is preserved.

FACSIMILE transmission unit accepts locked cartridges containing stacked letters (right). Machine extracts each letter from cartridge, unfolds it, and presents it to electronic scanner (lower left). After transmission of contents by scanner, letters are refolded and stacked in another locked box for temporary storage. At remote receiving point (inset) facsimile printers in background provide folded and edge-sealed, black-and-white copies of original letters. Copies are placed in envelopes by automatic inserter (foreground).

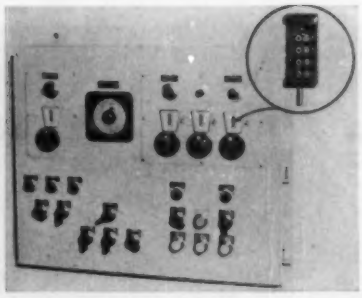
Five major pieces of equipment, and a special letter form, are involved in the facsimile system. In operation, sealed forms received at the Post Office are coded and time-stamped. They are then fed to a form processing machine which automatically trims the sealed edges of the forms and packs them in locked metal cartridges.

Cartridges containing unsealed letters are then inserted in a special machine that extracts each letter, unfolds it, presents it to an electron-

ic scanner, refolds it, and packs it in another cartridge for temporary storage. The form processing and handling equipment was developed by Pitney-Bowes Inc.; associated scanning equipment was supplied by Stromberg-Carlson Div., General Dynamics Corp.

At a receiving point, impulses generated by the scanner are converted to an exact black-and-white reproduction of the original letter by means of a Stromberg-Carlson facsimile printer. This unit was developed in conjunction with Haloid Xerox Inc.

As xerographically printed sheets flow out of the facsimile printer, they are mechanically folded and edge-sealed so that only the addresses are visible. Then they are transferred to an inserter developed by Bell & Howell Phillipsburg Co. The inserter automatically opens the flap of a window-type envelope, inserts a letter, seals the flap, and counts and stacks the envelopes for delivery.



DIGITAL readout counters, developed by Durant Mfg. Co., were specified by Wisconsin Electrical Mfg. Co. for use in this weighing control panel installed in a concrete batching plant. Controls automatically open and close valves or gates to admit materials to hoppers in the quantities indicated on the counters.

Since the scanning and printing system utilizes commercial coaxial cables or microwave communications links, industrial, commercial, and government applications are foreseen for the rapid transmission and reproduction of graphic information. Blueprints, photos, and handwritten or printed materials may be processed with equal facility by the facsimile system.

Joint Developments Permit Telephoned Data Transmission

TRANSMISSION of data over regular telephone lines, at speeds up to 150 characters per second, is possible with an electronic system de-

Patch Plug Redesign Permits Automatic Assembly

REDESIGN of patch plugs used in programming boards for data processing machines has opened the way for automatic assembly of the plugs at International Business Machines Corp. The plugs, connected to the ends of patch wires, are inserted in the programming boards in various patterns to set up desired circuits through the boards.

Major design change was substitution of a zinc die casting for a stamped metal plug nose. The die cast part was developed by IBM working in conjunction with Gries Reproducer Corp., and is made in volume on automatic die casting equipment.

As a result of the change, complete plugs each consisting of a die cast nose, a coiled spring, a bearing ball, and a plug sleeve can be assembled automatically on the equipment shown. The machine, developed by IBM engineers, produces assemblies at a rate of 140 plugs per minute.

In a subsequent assembly operation, finished program wires are produced on a multistation machine that performs twelve different operations in sequence. This unit was also developed by IBM engineers.

Quality advantages, in addition to production cost savings, are claimed for the redesigned plug. Using a ball-detent principle, the new plug achieves positive locking action yet is easy to insert and remove from the front of a programming board. With the previous design, positive seating and release of the plug nose was uncertain since the action depended on the spring characteristic of a small lip protruding from the stamping. Production tolerances were such that it was difficult to maintain the proper spring action with the stamped metal part.

NEW HUGHES MT-3
AUTOMATES JOB LOT PRODUCTION

The new Hughes MT-3 replaces from three to six conventional machines. It drastically reduces costs by bringing production line efficiency to small lot manufacturing of parts requiring face and other milling operations, drilling, boring, reaming and tapping. Operating from numerical instructions programmed on tape, the system functions completely automatically. The MT-3 has an absolute positioning accuracy of ±0.0005". Its part size envelope is a twelve-inch cube, but in many cases will machine parts up to 12" x 24" x 24".

For complete engineering specifications, firm price and delivery dates write, teletype (TWX INGL 4117) or call collect: HUGHES INDUSTRIAL SYSTEMS DIVISION, P. O. Box 90904, Los Angeles 45, California.

CREATING A NEW WORLD WITH ELECTRONICS

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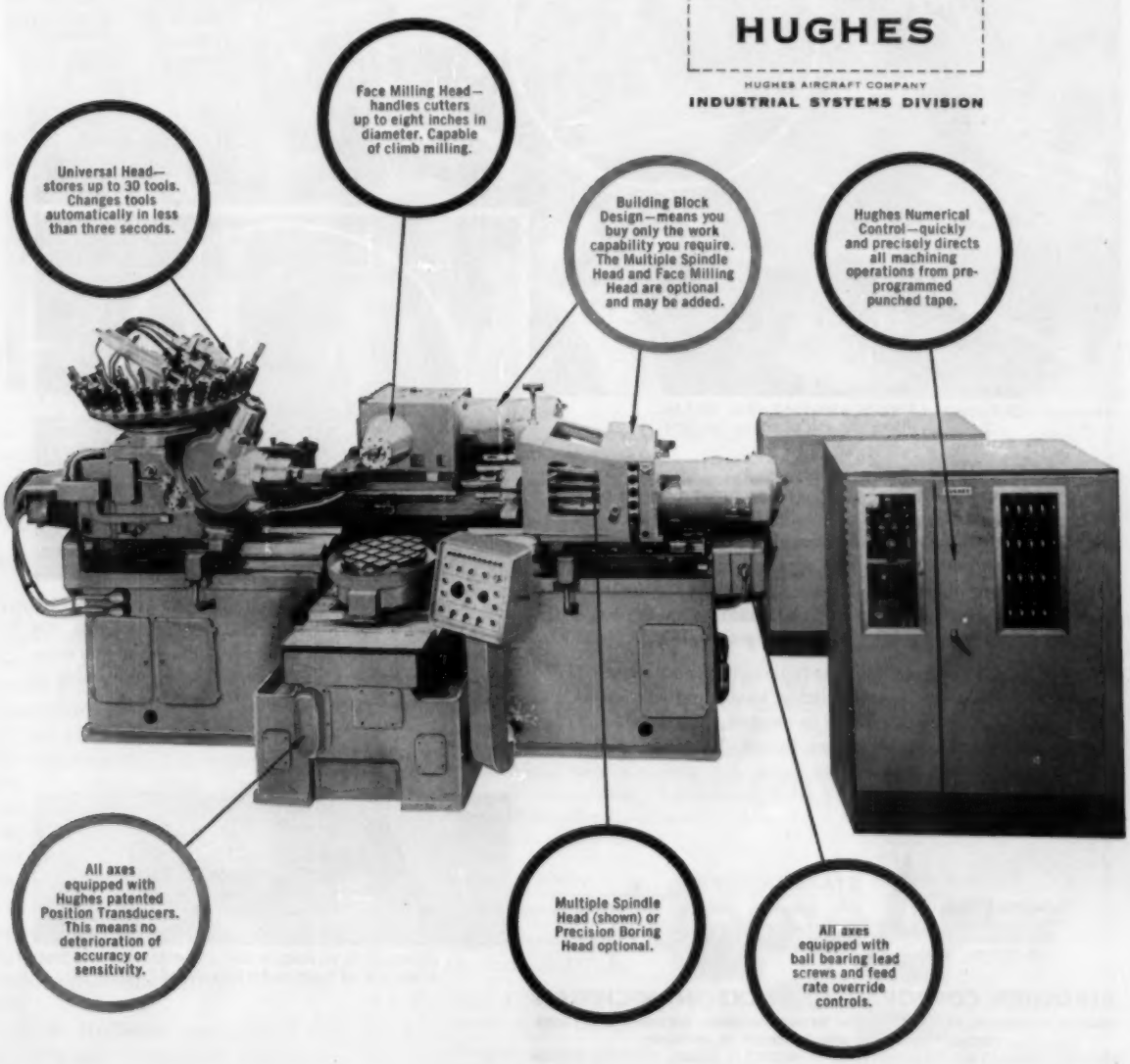
INDUSTRIAL SYSTEMS DIVISION


Universal Head—stores up to 30 tools. Changes tools automatically in less than three seconds.
Face Milling Head—handles cutters up to eight inches in diameter. Capable of climb milling.
Building Block Design—means you buy only the work capability you require. The Multiple Spindle Head and Face Milling Head are optional and may be added.
Hughes Numerical Control—quickly and precisely directs all machining operations from pre-programmed punched tape.
All axes equipped with Hughes patented Position Transducers. This means no deterioration of accuracy or sensitivity.
Multiple Spindle Head (shown) or Precision Boring Head optional.
All axes equipped with ball bearing lead screws and feed rate override controls.

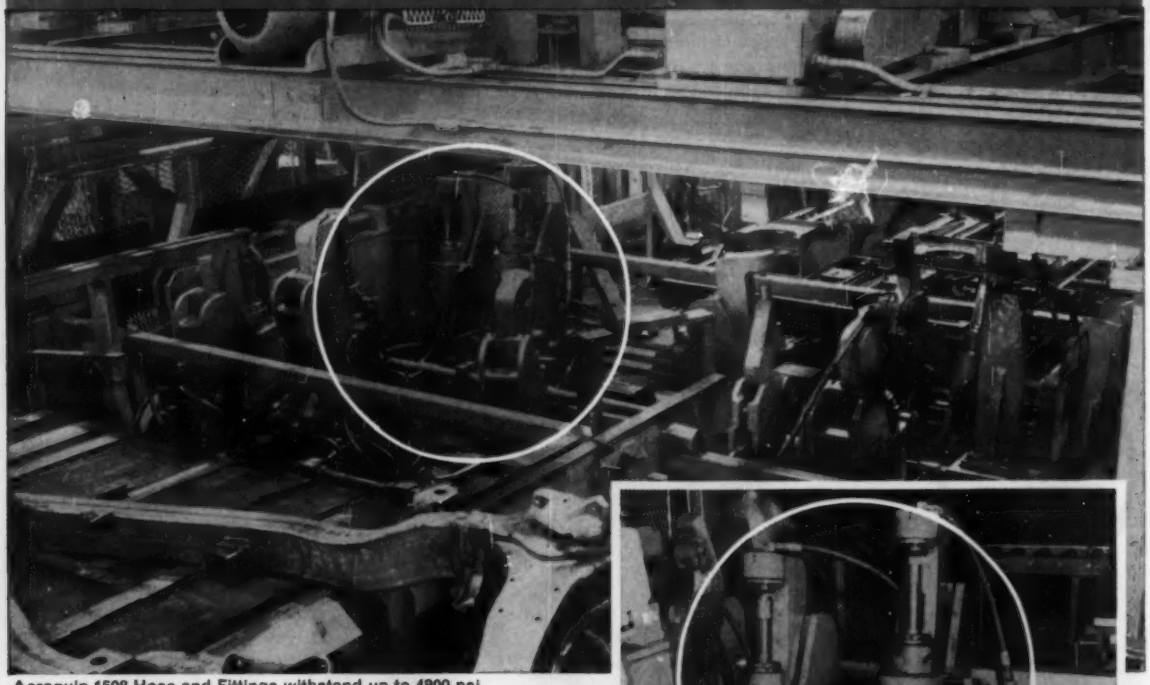
Circle 659 on Page 19

For 4800 psi PRESSURE SURGES

Tool Engineer Specifies

Aeroquip *Hose Lines and Reusable Fittings*

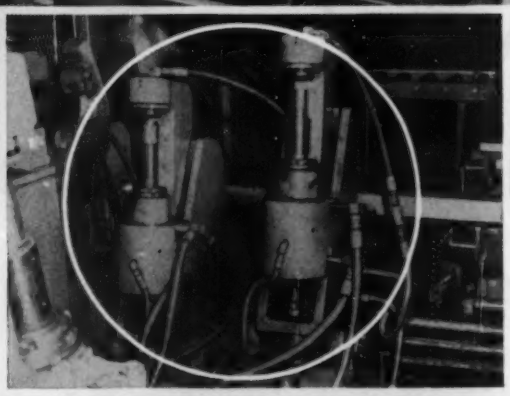
From job report by large automotive plant producing auto frames and stampings



Aeroquip 1508 Hose and Fittings withstand up to 4800 psi on this body bolt piercing machine.

The experience of this tool engineer has proved that a bulk stock of Aeroquip Hose and Reusable Fittings can expedite the design and maintenance of automated production machinery such as automatic body bolt piercing machines. In this application Aeroquip Very High Pressure Hose, under constant flexing and pressure surges up to 4800 psi, helps avoid down-time and keeps production running smoothly.

When infrequent Aeroquip Hose replacements are required they can be made on the job, quickly, easily and with minimum down-time. Hose can be cut as needed, no special tools are required. Fittings can be reused. Result—fewer and briefer interruptions to work flow.



Your Aeroquip Distributor is a fluid line specialist. He will give you a copy of our industrial Catalog No. 204 and explain why you are in good hands when you consult with Aeroquip. Call him. His telephone number is in the "Yellow Pages" under "Hose."

Aeroquip is so easy to use—your inventory is just a few feet of hose and a handful of fittings.

STANDARDIZE ON Aeroquip

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AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN CANADA, U.S.A. AND ABROAD

Circle 667 on Page 19

veloped by Digitronics Corp. Designated Dial-o-verter, the system was created to function with the Bell Telephone System's Data-Phone, a device that links business machines via telephone lines.

Using the equipment, a person can dial another station and send or receive data in machine language. The system refuses to send data unless the transmission line is acceptable, and will permit unattended operation. Since data are transmitted over the regular telephone network, charges are the same as for local or long distance conversations, including night rates when applicable.

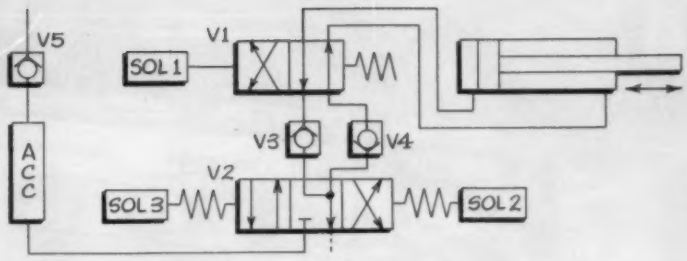
A complete system includes a Data-Phone, a Dial - o - verter coupler, and any of the data media in common use, including paper tape, punched cards, or magnetic tape. When transmitting, a tape reader, card reader, or magnetic tape handler supplies data. When receiving, the coupler functions with a paper tape punch, card punch, or magnetic tape handler.

Features of the system include error reporting, error retransmission options, and double parity, according to **A. A. Auerbach**, president of Digitronics. In addition to relatively high speed transmission, the system provides flexibility of operation in that data can be sent by one medium (such as paper tape) and received by another (such as cards or magnetic tape), and vice versa.

Leasing Plan Covers Resistance Welding Machines

FINANCING PLAN formulated by Thompson Electric Welder Co. and General Electric Credit Corp. (the holding firm) will allow users of resistance welding machines the option of leasing instead of buying the equipment. On request, welding machines, either standard or modified slightly to suit a customer's requirements, will be leased for a maximum of 60 months. Leasing charges will depend upon the fair value of the equipment. Numerous options are available, including straight time payments in which a customer obtains title to the property.

R. P. Hedblom, president of the welding equipment firm, anticipates



Accumulated Air Smooths Piston Reciprocation

CONTROLLED acceleration and deceleration of a reciprocating piston, and reduced air consumption, are features of a pneumatic circuit developed by Mechanical Air Controls Inc. The circuit uses standard pneumatic components including two solenoid-operated direction controls (*V*1 and *V*2 in diagram), three check valves (*V*3, *V*4, and *V*5), and a small accumulator. The pneumatic cylinder requires no cushions.

Operation of the circuit may be followed by reference to the accompanying pneumatic circuit diagram and sequence chart.

Startup Condition. Initially, the piston is in its fully retracted position and the solenoids are de-energized. The accumulator is charged.

Begin Advance Stroke. *SOL* 1 and *SOL* 2 are energized, shifting the spools of valves *V*1 and *V*2 to positions admitting air from the accumulator to the blind end of the cylinder through check valve *V*4. The rod end of the cylinder is exhausted through check valve *V*3. Air from the accumulator is used to accelerate the piston, and line air entering check valve *V*5 keeps it moving.

Decelerate and Charge. At a predetermined point in the advance stroke, *SOL* 2 is de-energized and *SOL* 3 is energized. This action shifts the spool of valve *V*2 to a position admitting air from the rod end of the cylinder into the accumulator through check valve *V*3. As pressure in the accumulator builds up above line pressure, check valve *V*5 closes. Accompanying this pressure buildup is smooth deceleration of the piston as the air in the rod end of the cylinder is compressed. Shifting of *V*2 also cuts off the air supply to the blind end of the cylinder. Air already in the cylinder is retained by check valve *V*4. This air expands as the advance stroke is completed, reducing the pressure in the blind end.

Begin Return Stroke. To return the piston, *SOL* 1 and *SOL* 3 are de-energized and *SOL* 2 is energized. This admits air from the accumulator through check valve *V*4 to the rod end of the cylinder, accelerating the piston in the return direction. Air is exhausted from the blind end of the cylinder through check valve *V*3. Line air, entering the rod end of the cylinder through *V*5, keeps the piston moving after the acceleration period.

Decelerate and Charge. At a predetermined point in the return stroke, *SOL* 2 is de-energized and *SOL* 3 is energized. This action shifts the spool of valve *V*2 to a position admitting air from the blind end of the cylinder into the accumulator through check valve *V*3. Deceleration occurs as pressure builds up in the accumulator. Air in the rod end of the cylinder is retained by check valve *V*4 and allowed to expand as the return stroke is completed.

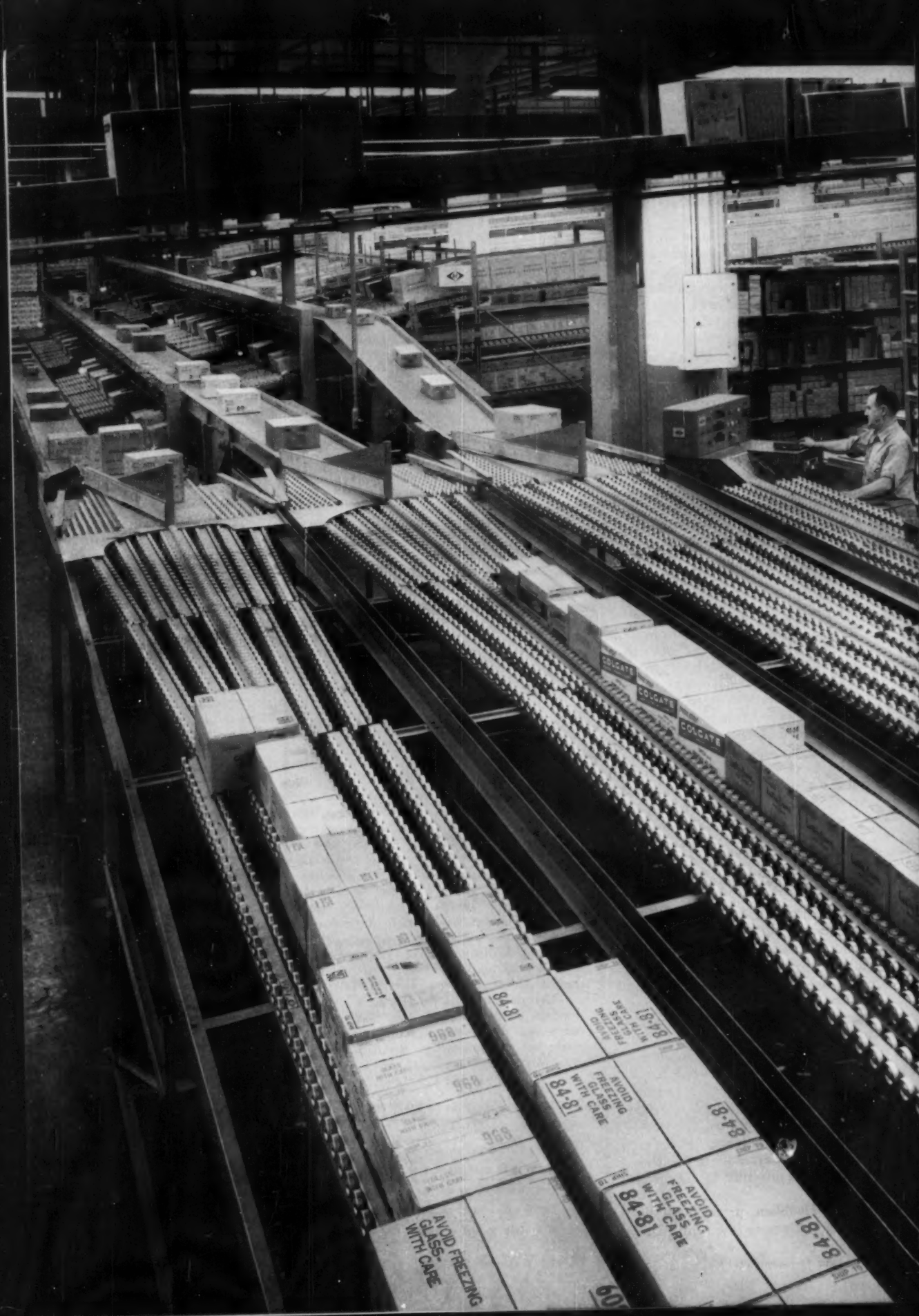
Complete Return Stroke. With the piston in its fully retracted position, *SOL* 3 may be de-energized. This will place the spool of valve *V*2 in its neutral position, restoring the system to the startup condition.

Operating speed of the cylinder is determined by the setting of a pressure regulator on the air supply line. Since air is retained in the system, and line air is used during only a portion of a stroke, the circuit operates with relatively low air consumption. By replacing valve *V*1 with a 4-way, three position, closed center directional control valve, the piston can be stopped at any point in a stroke and/or inched.

Operation or Position	SOL 1	SOL 2	SOL 3
1 - Startup condition			
2 - Begin advance stroke	■	■	
3 - Decelerate and charge	■		■
4 - Begin return stroke		■	
5 - Decelerate and charge			■
6 - Complete return stroke			

■ Solenoid energized

□ Solenoid de-energized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Circle 661 on Page 19

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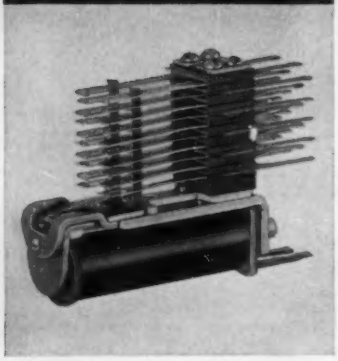

. . . featuring new high-voltage types for test equipment or other high-voltage applications.

THE insulation in the new relays withstands 1500 volts A.C.—three times normal. These high-voltage models are available in Types A, B and E. They are the latest additions to the Stromberg-Carlson line of twin contact relays—all available for immediate delivery.

The following regular types are representative of our complete line:

***Type A:** general-purpose relay with up to 20 Form "A" spring combinations. This relay is excellent for switching operations.*

***Type B:** a gang-type relay with up to 60 Form "A" spring combinations.*

***Type BB:** relay accommodates up to 100 Form "A" springs.*

***Type C:** two relays on the same frame. A "must" where space is at a premium.*

***Type E:** has the same characteristics as the Type A relay, plus universal mounting arrangement. Interchangeable with many other makes.*

Details on request. In Atlanta call TRINITY 5-7467; Chicago: STATE 2-4235; Kansas City: HARRISON 1-6618; Rochester: HUBBARD 2-2200; San Francisco: OXFORD 7-3630. Or write to Telecommunication Division, 111 Carlson Road, Rochester 3, New York.

STROMBERG-CARLSON
A DIVISION OF
GENERAL DYNAMICS

Circle 662 on Page 19

that many manufacturers will use the plan as a means of obtaining modern welding machines for a broad variety of assembly operations without materially increasing their capital expenditures.

According to Hedblom, if the lessee does not have equity in the equipment, or does not intend to in the future, he may include his leasing costs as tax deductible operating expenses.

Computer Users Organize To Exchange Information

AT A recent meeting held in Milwaukee, representatives of various computer user groups decided that there be formed an organization, provisionally known as the Joint Users Group. The objective of the organization is the establishment of communciation among computer user groups to promote study, exchange of information, and co-operative effort in areas of common interest.

These areas include:

- Common programming languages and other means of communication between computing machines.
- Establishment and maintenance of standards for communication and distribution of computer programs and techniques.
- Exchange of information on problems arising from the operation of a computer installation.
- Communication of methods and techniques for comparing the effectiveness of computer problem solving techniques.
- Consideration of hardware standards in co-operation with other interested agencies.

At the meeting, an invitation was received from the Council of the Association for Computing Machinery "to organize within the ACM and to take advantage of the facilities and services of the ACM to implement (this multiple objective)." Further action on this matter is expected at a Dec. 16 meeting of the Joint Users Group in New York.

DUAL SPEED drive for press brakes advances the ram at a rapid speed and then slows it down prior to contacting the work. Developed by Verson Allsteel Press Co., the drive increases the production rate of a press brake over that where a single, slow speed is used in bending large sheets. Return of the ram is at the higher speed.

New Slate of Officers Elected By NMTBA

AT THE ANNUAL meeting of the National Machine Tool Builders' Association, new officers were elected for the coming year. **Everett M. Hicks**, vice president and general manager, Grinding Machine Div., Norton Co., was elected pres-

---

ATOMIC POWER equipment plant of General Electric Co. has taken a step toward automation with the installation of a tape-controlled drilling machine. In the illustration, a numerically-controlled turret drill finishes the last of 17,200 perfectly spaced holes in special plates. One tape-controlled machine is now in operation, a second is scheduled to be installed soon, and plans are to have six more tape-controlled machines installed later this year and in 1961. The new machines are expected to play a major role in maintaining high standards of quality control and in cutting production costs. The Burg Tool Mfg. Co. Inc. drilling machines are equipped with General Electric Co. Mark II numerical position controls.

around the triangle

VERSATILE SENSING ELEMENT

Ultraviolet detector tube developed by the Instrument Div., Thomas A. Edison Industries, can operate a relay directly to perform a variety of alarm and control functions. The tube is insentive to sunlight, cosmic radiation, infrared radiation, and light from incandescent and fluorescent sources. Typical applications include detection of fire, flame-out in combustion chambers, and arcing of electrical devices. Where a gas, smoke, or dust will attenuate or block radiations from an ultraviolet source, detection of that material may be accomplished. About the size of a golf ball, the gas discharge type tube is normally connected in a simple electrical circuit operated from a standard 60 cps ac power source.

TROUBLESHOOTING BY TELEPHONE

Users of Daystrom Inc. electronic computer control and data logging equipment may now receive programming and troubleshooting assistance by means of a telephone call to the company's Control Systems Div. in La Jolla, Calif. With the service, available at a nominal fee, a console in the manufacturer's office may be connected by telephone line to a similar console at the installation. Once a connection is made, trained Daystrom personnel can supervise and control the functioning of the user's system from the service location. For example, if a programming difficulty is involved, the user can transmit his program to the console at La Jolla. There, a programmer will study the resulting copy and punch the necessary changes in paper tape to reprogram the user's computer. Troubleshooting assistance may be given by voice telephone after tests have been run on the console.

CUTS CORROSION IN VESSELS AND PIPES

An electrochemical system, developed by Continental Oil Co., promises to reduce corrosion of vessels and related piping used in the storage and processing of certain corrosive acids and caustics. Worldwide manufacturing and marketing rights for the system, designated Anatrol, have been assigned to the Rubicon Div., Minneapolis-Honeywell Regulator Co. In operation, a "passive film" is developed and maintained on the internal surfaces of a metal vessel when a direct current is passed from a special electrode, through the corrosive liquid, to the vessel. The film makes the steel surfaces resistant to corrosion by chemicals such as sulphuric, phosphoric, and nitric acids; sodium and potassium hydroxide; aluminum sulphate; and ammonium nitrate. Applications for the system are foreseen in storage tanks, tank cars, trucks, barges, and process vessels exposed to such chemicals.

READS PENCILED NOTATIONS ON CARDS

Handwritten markings, made in selected areas of special tabulating cards, may be sensed by an optical scanning device designed by Remington Rand Univac Div., Sperry Rand Corp. Appropriate code holes are then punched automatically in the same cards at a rate of 150 cards per minute. The system, designed to eliminate the need for manual card punching from original source documents, can be used for inventory, production control, payroll accounting, and statistical data processing. In use, as many as 40 columns of information may be marked with a soft pencil on one side of a standard card. The marking area for each position on the card (which determines the digital value of the mark) is a relatively large rectangle, so that only a reasonable degree of precision is required of a person marking the card. Marks may be in the form of check marks, lines, circles, or numerals. If a card is improperly marked, the scanner will either stop until the error is corrected or segregate the defective card and continue operating.

AUTOMATION

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403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
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409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
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414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
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419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
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425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
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429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

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Circle item number for further information on anything described or advertised in this issue

CARD INVALID WITHOUT COMPANY NAME—TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE_____

STATE _____

This card good until Feb. 15, 1961

AUTOMATION DECEMBER 1960

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
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FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States
—POSTAGE WILL BE PAID BY—

AUTOMATION
Penton Building
Cleveland 13, Ohio

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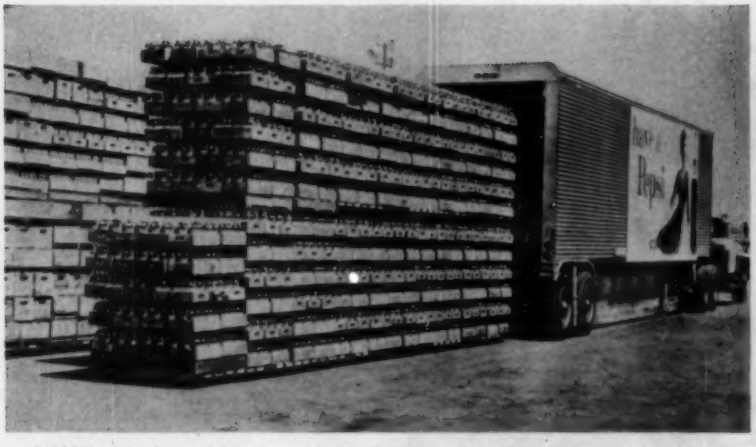


CAPABLE of loading or unloading a 30,000 lb bundle of steel beams in 3 minutes, trailer has its own hydraulic system which picks up a load, holds it while traveling, and unloads it at the job site. Designated Straddle Trailer, the unit is manufactured by Challenge-Cook Bros. Inc. In operations, a load to be moved is first stacked on pallets or wood blocks. A driver then backs the trailer over the load and operates the hydraulic lifting mechanism by control levers. The mechanism picks up the load—including the pallets—and automatically centers the load as it is raised to transport position. To unload, the driver moves a lever which operates the hydraulic mechanism to lower the load, and drives the trailer away.

ident of the association; **Francis J. Trecker**, president, Kearney & Trecker Corp., was elected first vice president, and **Wallace E. Carroll**, president, American Gage & Machine Co., was elected second vice president. **Lawrence C. Gleason**, president and general manager, Gleason Works, was elected treasurer, and **Grayson M. Stickell**, president and general manager, Landis Machine Co., was re-elected secretary.

Coil Stock Used In Can Manufacturing

DEVELOPMENT of a quality control system now allows can manufacturers to substitute coil stock for prime sheet in high-speed multiple die presses. The basis of the new system, designed by Logic Systems Inc., is a simultaneous position detector which monitors die press operations. With computer and memory controls the system can monitor not only imperfectly-formed can parts, but also imperfections in the tin plate itself.

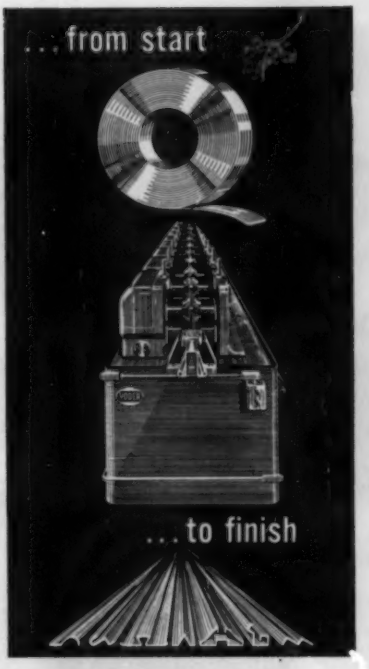
When a multiple die press is equipped with the new control, coil stock can be fed directly into the press. As the coil unwinds, areas containing imperfections are spotted and signals are sent to a master computer. This enables the computer to judge when can parts formed from imperfect stock will come from the press. As the imperfect parts emerge, they are automatically rejected; all other parts, meeting specifications, pass through.

Punched Cards Program Automatic Wiring Analyzer

DEVELOPMENT of an automatic wiring analyzer that can check up to 6000 circuit assemblies for current continuity and leakage has been announced by Hughes Aircraft Co. The analyzer is readily adaptable to product changes by making new connector cables and preparing new test cards and inserting them in the machine.

Tests are controlled by programmed International Business Machines Corp. cards corresponding to the wiring diagrams of circuits being checked. Each circuit requires one card, and 60 cards can be processed per minute.

In operation, a unit to be tested is connected to the wiring analyzer and a set of cards is placed in an IBM card reader. As the cards complete their test cycles, they automatically fall into different bins which classify the types of circuit failures and their locations in the assembly. Leakage failures are pinpointed by recycling trouble cards, one at a time, through the reader. A fault isolation panel on the an-



YODER ROLL-FORMING EQUIPMENT

Profits are available to you through the production of many shapes in metal... made with precision and economy on Yoder Cold Roll Forming Equipment.

Produce tubular, ornamental or structural shapes from a variety of metals in widths from a fraction of an inch up to 80 inches or more, and in stock up to ¾" thick. Your investment is comparatively modest, and with proven low operating costs, will give you one of the most profitable operations in your plant.

Experienced Yoder engineers will, without obligation, study your annual metal forming requirements. Many times they can point out that the installation of roll forming equipment would—even if operated only intermittently—soon justify its initial cost.

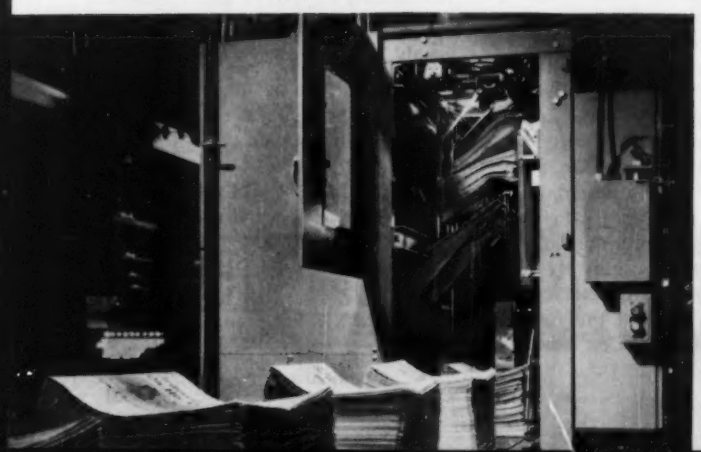
Send today for this comprehensive, 88-page illustrated text. It fully describes Cold Roll Forming Equipment, processes and products.

THE YODER COMPANY
5526 Walworth Avenue • Cleveland 2, Ohio

ENGINEERING YODER MANUFACTURING COLD ROLL FORMING MACHINES

Circle 663 on Page 19

No more hand stacking. This newspaper counter-stacker counts and stacks newspapers automatically—and can be programmed to automatically vary the stacks to meet route schedules.



No more dry pumping. Cutler-Hammer's new development—an automatic pump off control for stripper oil wells—stops the pump when oil has been lifted. Saves the pump, ups production.

What's new in control for automation?

A blast furnace that charges itself

More efficient automation because the Cutler-Hammer control systems man was called in at the start of planning. The art of charging a blast furnace is now a science.

Cutler-Hammer control engineers, with the furnace builders, worked three years to put all charging control functions into one integrated system. Now, the proper material in the proper amounts, all in a proper sequence are delivered to the furnace bell—automatically.

Every step of the operation can be checked visually on master control panels. Nothing is left to chance. The added cost of this kind of charging control is relatively insignificant. Complete flexibility in selection of furnace charging programs now makes possible optimum blast furnace performance.

Why you should call in the electrical control man early. Cutler-Hammer has been increasing productivity and lowering costs for many different companies in many different industries for years. This is a major reason why Cutler-Hammer should be called when you *start your automation planning.*

The company on the move. There's a new vitality at Cutler-Hammer—a new desire to solve problems. We've planned for the gigantic expected growth of the sixties and now we're ready—with new plants, new engineering talent, new and better products. We'd like to tell you about ourselves if you're planning ahead. Contact the Cutler-Hammer sales office nearest you.

Automation is more efficient when the control expert is called in early.

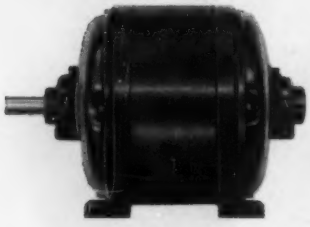
WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

Circle 664 on Page 19

USE MOTOR LOAD



TO CONTROL MACHINE OPERATIONS

Using motor load as the measured variable, API's Load Sentry is probably the most versatile—and perhaps the simplest—discrete machine control you're likely to find around. You can use it to switch from one feed rate to another, to measure actual accumulated work time or work count, to protect against mechanical or electrical overload from such causes as faulty work positioning, excessive torque, etc. All these conditions—and many more—are accurately reflected in motor-load current, a convenient means of control actuation.

Fast-acting Load Sentry will respond in less than 0.2 seconds to motor-load variations as little as 5% (in some cases 3%) of whatever norm you select. A simple index-pointer setting establishes the motor-load limit.

Built around the API contact meter-relay, Load Sentry is available as a simple contacting meter or a complete control package, ready to install. It has the inherent reliability of the locking-coil meter-relay: you can expect at least ten million operations without failure.

Load Sentry can be supplied to measure either amps or watts. It can be damped to limit response to steady overloads of up to three seconds' duration, and can include provision for start-up time delay. Bulletin 106-C will give you more detailed information.

api **ASSEMBLY PRODUCTS, INC.**
CHESTERLAND 27, OHIO

alyzer indicates, by lights, exactly which wires in the circuit are faulty.

A functional tester on the analyzer checks for proper operation of all switches and relays and checks the values of electrical components such as resistors, transformer and relay windings, and diodes.

ACTING as representative to a newly organized Sectional Committee of the American Standards Association will be **Mayo A. Harvey,** manager of office operations, General Foods Corp. The ASA committee is responsible for developing American office machines standards. The new committee, known as X4, has provided for representation from manufacturers, users, and general interest groups. At its recent organizational meeting, the committee voted unanimously to request representation from the National Office Management Association.

Automated Process Reclaims Germanium Scrap

SOLID-GAS REACTOR is used in an automated process for reclaiming high grade germanium scrap of 40 ohm-cm or better resistivity rating. The process, developed by High Purity Metals Inc., can accept various types of scrap such as

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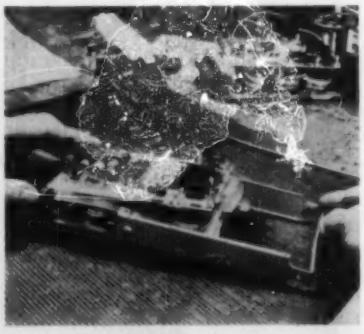


POTTED SUBASSEMBLIES, such as the plug-in unit shown, often have the problem of the liquid potting resin leaking through the connector, fouling pins. A method employed by Librascope Div., General Precision Inc., solves the problem by covering the terminal side of the connectors with a foamed elastomer pad before the unit is assembled. This method performs a dual function. In addition to preventing leakage of the epoxy resin, it provides a nonrigid installation for the connector terminals to prevent electrical failures.

Circle 665 on Page 19

Capacity of this production storage conveyor is 1400 tanks, of 24 different models. Call-out is automatic, controlled by push button.

24 different tank models, ready for call-out, on a single automatic storage line

Production storage, as illustrated in the picture above, is a cost-saving production technique that is being used in more and more plants.

This conveyor takes the production of two-shift tank fabricating operations and holds it in instantly available, out-of-the-way storage for the one-shift assembly department. Console controls deliver the tanks to assembly automatically, in the desired order and quantity.

The production, or in-process, storage system pictured uses an MHS Power and Free Conveyor. Power and Free offers the ultimate in versatility and flexibility, and in the new MHS design its basic cost approaches that of conventional overhead conveyors. However, MHS uses many types of conveyors for in-process storage, including Monoveyors, accumulation types, tow-lines, etc., to fit particular plant and manufacturing needs and budgets.

Whatever the conveyor utilized, MHS builds savings and economies into these systems. Multiple handling is ended, there are no delays because of supply failure. Time variations in production operations are compensated to achieve smooth, economical operations. In addition, overhead types operate in unused air space, releasing valuable floor areas for productive use.

Discuss production storage with the expert MHS engineer. He can show you how to apply its advantages to your plant.

MECHANICAL HANDLING SYSTEMS INC.

Manufacturing Engineers

4632 NANCY AVENUE, DETROIT 12, MICHIGAN

Factories: Detroit, Mich., Clark, N.J., Fairfield, Iowa, Windsor, Ont.

Branch Offices in Principal Cities

In Canada—Canadian Mechanical Handling Systems Ltd., Windsor, Ont.

Circle 666 on Page 19

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders, Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 "V" Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

crystal ends, high grade scrap, broken slices, or high grade sawdust; in either single crystal, polycrystalline, or doped germanium forms. This material is then refined by the automatic process to produce the basic germanium from which semiconductor manufacturers can pull single crystals.

Immersion Plating Method Requires No Electrodes

ELECTROLESS PLATING of printed and etched circuits is possible with the development of an immersion rhodium plating bath introduced by Technic Inc. The immersion bath is a stable solution which will deposit a tight-grained, pore-free deposit of rhodium on copper or nickel. No electrical contact is required to deposit a solderable, corrosion-resistant finish. **Frank K. Smith**, president of the firm, said a five-minute deposit over copper will withstand a 30-minute immersion in a 50 per cent nitric acid solution. Other applications for the process include protecting component leads, contacts, and connectors, and applying decorative finishes.

SPOTLIGHTING PEOPLE

Ronald Holt appointed project engineer and machine designer for Battle Creek Packaging Machines Inc. . . . **Walter P. Hooper** named vice president and general manager of Panellit Div. at Information Systems Inc. . . . **Arthur E. Stukey** appointed manager of Standards Dept. and **Harley King** named manager of Manufacturing Controls, two newly formed departments of Staff Industrial Engineering at Thompson Ramo Wooldridge Inc. . . . **A. F. Sammet** joined Autonetics, Div., North American Aviation Inc. as assistant to the vice president of Industrial Products. . . . **Oscar Ahlers** appointed vice president and general manager and **Roy Heldenbrand** named vice president of operations, both at Sheffield Corp. . . . **Donald R. Piatt** appointed vice president of engineering and research for Veeder-Root Inc. . . . **Kurt W. Leibfritz** named chief engineer, Air Valves, at Hannifin Co. . . . **Richard D. Sevick** appointed supervisor of abrasive cutting machine development for the Allison-Campbell Div., American Chain & Cable Co. Inc. . . . **Charles E. Peterson** named division manager of the Mackintosh-Hemphill Div., E. W. Bliss Co. . . . **Henry E. Eiszler** appointed operations manager and **Lynford W. Gilbert** named automation systems project manager, both for the Electronics Div., Rheem Mfg. Co. . . . **Stanley E. Jacke** appointed vice president in charge of engineering and research in the Power Div., Branson Instruments Inc. . . . **Edward B. Delany** named product line manager of Process Control for the Instrument Div., Perkin-Elmer Corp. . . . **Armand T. Audette** elected vice president for manufacturing at Allied Control Co. Inc. . . . **Roy E. Lambert** appointed assistant general manager of the Indianapolis ball and roller bearing plant of Link-Belt Co. . . . **Harry L. Hildebrand** named manager of process and design engineering and **John G. Musselman Jr.** appointed manager of the Fabricating Div., both at Taylor Fibre Co. . . . **Charles C. Snider** elected vice president of

FINISHING MACHINE is said to be able to produce a finish equal or superior to buffing on parts with intricate detail, ornamentation, or complex shape. Parts which can be processed range from watch screws to automobile headlamps. The machine, designated Harperizer, uses a fine loose abrasive with a high centrifugal force to hold parts and media together in a tight mass. Roto-Finish Co. is licensed to manufacture the machine.

Sparks Perforate Tape To Record Digital Data

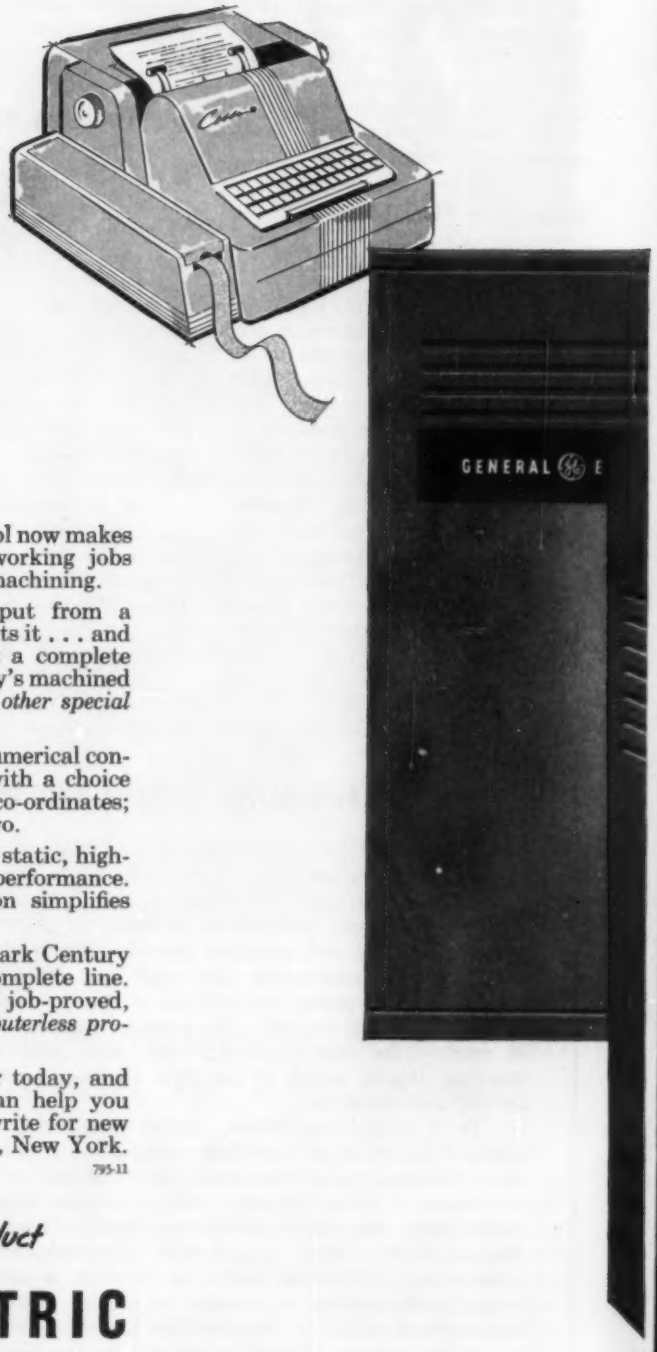
DIGITAL ENCODING of paper tape is accomplished by electronically incinerating small holes in the paper, with a recorder developed by Advanced Instrument Corp. Up to eight channels may be used, and information recorded on the tape is both visually readable and machine sensible. Suitable for in-plant industrial and commercial data gathering systems, the light weight and low power consumption of the unit permit remote-area and field use as well. An accessory tape reader is capable of reading the tape photoelectrically and providing electrical impulses directly usable by standard business machines, display devices, and computers.

In a typical installation, digital transducers are used to gather information on variables—temperatures, pressures, flows, meter readings, numerical counts, etc.—and convert their values to patterns of contact closures. When equipped with an optional programmer, the recorder then scans the digital transducers and converts their outputs into serially (time-sequenced) encoded pulse trains. When the pulses are received, a perforation generator in the recorder is actuated to produce holes in the tape. An electrical output is also available for telemetering purposes.

A photoelectric digitizer, developed by the company, can be adapted to convert the outputs of analog transducers or meters to discrete numbers that can be displayed, printed, or fed to a recorder. The unit can be attached to standard dial-type instruments, and can also be used with rotating shaft devices. Output is in electrical pulse form to represent temperature, pressure, speed, time, position, etc., as measured by the meter or transducer.

NOW...

automatic contouring without a computer



New General Electric Mark Century numerical control now makes *computerless programming* a reality for most metalworking jobs . . . including all circular, angular, and straight-line machining.

This new control system takes punched-tape input from a standard automatic typewriter . . . reads and interprets it . . . and automatically commands the machine to carry out a complete machining cycle. Producing more than 85% of industry's machined parts can be as simple as that—*with no computer or other special equipment necessary!*

Contouring or absolute positioning—Mark Century numerical control comes in a compact, "building-block" package with a choice of: 1-, 2-, 3-, 4-, or 5-motion positioning to absolute co-ordinates; 2- or 3-motion contouring; or a combination of the two.

Solid-state devices, modular construction—Completely static, high-speed logic circuits mean long life and dependable performance. New General Electric plug-in, modular construction simplifies maintenance and inspection.

Another member of the G-E program control family—Mark Century control is the newest addition to General Electric's complete line. It supplements the industry-renowned Mark series of job-proved, low-cost numerical positioning control to bring *computerless programming* to America's metalworking industry.

See your machinery builder or G-E Sales Engineer today, and find out how General Electric numerical control can help you increase productivity and cut machining costs. Or, write for new bulletin to General Electric Company, Schenectady 5, New York. Specialty Control Dept., Waynesboro, Va. 795-11

Progress Is Our Most Important Product

GENERAL ELECTRIC

NEW MARK CENTURY

NUMERICAL CONTROL
FOR AUTOMATION

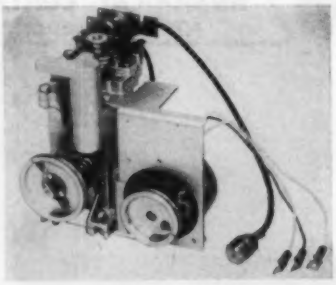
NUMERICAL CONTROL

Circle 668 on Page 19

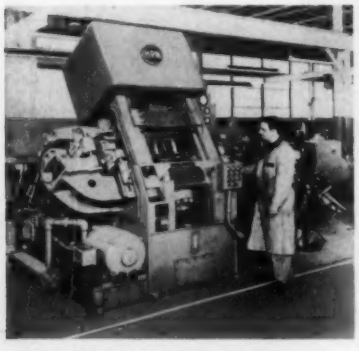
Consolidated Electrodynamics Corp. . . . **Leon Mollick** named manager of engineering for the Industrial Equipment Div., Baldwin-Lima-Hamilton Corp. . . . **Ross D. Randall** joined Annin Co. as manager of engineering.

SPOTLIGHTING PLANTS

Optical Gaging Products Inc., subsidiary of Ex-Cell-O Corp. has opened a West Coast branch in Downey, Calif. The company will manufacture chart-gages and offer engineering services in the field of optical gaging. . . . **TRW Computers Co.** is the new name for the Thompson-Ramo-Wooldridge Products Co. The company will continue to function as a computer division of Thompson Ramo Wooldridge Inc. with headquarters in Beverly Hills, Calif. . . . **Avery Label Co.** has opened a new manufacturing plant in Cleveland. The 18,000 sq ft plant will supply adhesive labels and adhesive decorative trim products. . . . **American Brake Shoe Co.** has acquired the assets of Herscott Corp., a manufacturer of electrical resistance heating units. The corporation will be liquidated and will be operated as the Reslec plant of American Brake Shoe's AmForge Div. . . . **Crompton & Knowles Corp.** has announced the merger of the F. B. Redington Co. into its packaging machinery division. With the acquisition of this company, the division will provide a broader line of cartoning, wrapping, labeling, and case packing machinery, and will have increased facilities for designing specialized packaging equipment for individual company needs. . . . **Robertshaw-Fulton Controls Co.** has opened a Thermostat Div. manufacturing plant just east of Pittsburgh. The new plant, which occupies 7½ acres, will manufacture gas appliance controls. . . . **Racine Hydraulics & Machinery Inc.** announced the formation of a foreign subsidiary, Racine Hydraulics Co. Ltd., with headquarters at Zug, Switzerland. The subsidiary will provide the parent firm with fast service to European customers and act as a technical liaison between Racine Hydraulics and its foreign licensees. . . . **Minneapolis-Honeywell Regulator Co.** has changed the name of its Datamatic Div. to Electronic Data Processing Div. Reason for the change is to make the division's name clearly express its product line and to identify the products more closely with the company. . . . **Hewitt-Robins Inc.**, manufacturer of rubber belting and machinery components for material handling systems, has acquired the assets of Union Chain & Mfg. Co., manufacturer of conveyor and power transmission chain and sprockets. Plans are to operate Union Chain as a division of Hewitt-Robins. . . . **Bemis Bro. Bag Co.** is building a 50,000 sq ft plant at Muskegon, Mich. It will manufacture molded cellulose products which are used as protective shipping materials. . . . **Norden Div., United Aircraft Corp.** has moved all of the operations of the Data Systems Dept. to Costa Mesa, Calif. . . . **Computer Dept., General Electric Co.**, has established a new development-engineering unit that is known as Peripheral Equipment Engineering. It will be responsible for developing all computer accessory equipment comprising integrated data-processing systems.



TRANSDUCER developed by Taylor Instrument Companies converts pneumatic pressure signals into proportional values of electrical resistance. The unit, designated Servomatic Transducer, was designed especially to serve as a link between pneumatic transmitters used in process control systems and computers or data loggers. For example, the device could enable a chemical plant to add a computer to a process which already has pneumatic control. Major elements of the transducer include a pneumatic servomotor and a precision potentiometer. The shafts of the servomotor and potentiometer are connected by a pulley and cable system, so that rotation of the servomotor results in a proportional rotation of the arm of the potentiometer. Thus, a change in resistance may be measured between the arm of the potentiometer and one side as the pneumatic input signal to the servomotor varies. If a voltage output is desired from the unit, a fixed voltage from an external source is applied across the potentiometer. Then, a portion of this voltage—reflecting the magnitude of the input pneumatic signal—may be taken from the potentiometer. Arrangement can include a second potentiometer for obtaining two isolated electrical outputs from the same transducer. Alarm contacts that operate when the servomotor receives an out-of-limits pneumatic signal are optional. A pulsation dampener is also available that smooths out input signal fluctuations. This option is useful when pulsating inputs, such as flow signals, are being handled.



TRIPLE-ACTION hydraulic press operates a special die to blank parts with surface accuracies within 0.0005-inch. The blanking punch works against a bottom punch or die cushion, while a third action clamps the material firmly during the blanking stroke. All press actions are synchronized, and pressures for the three actions may be adjusted for various types of metal. The press, manufactured by Hydraulic Press Mfg. Co., cycles at speeds up to 100 strokes per minute.

MEETINGS & EVENTS

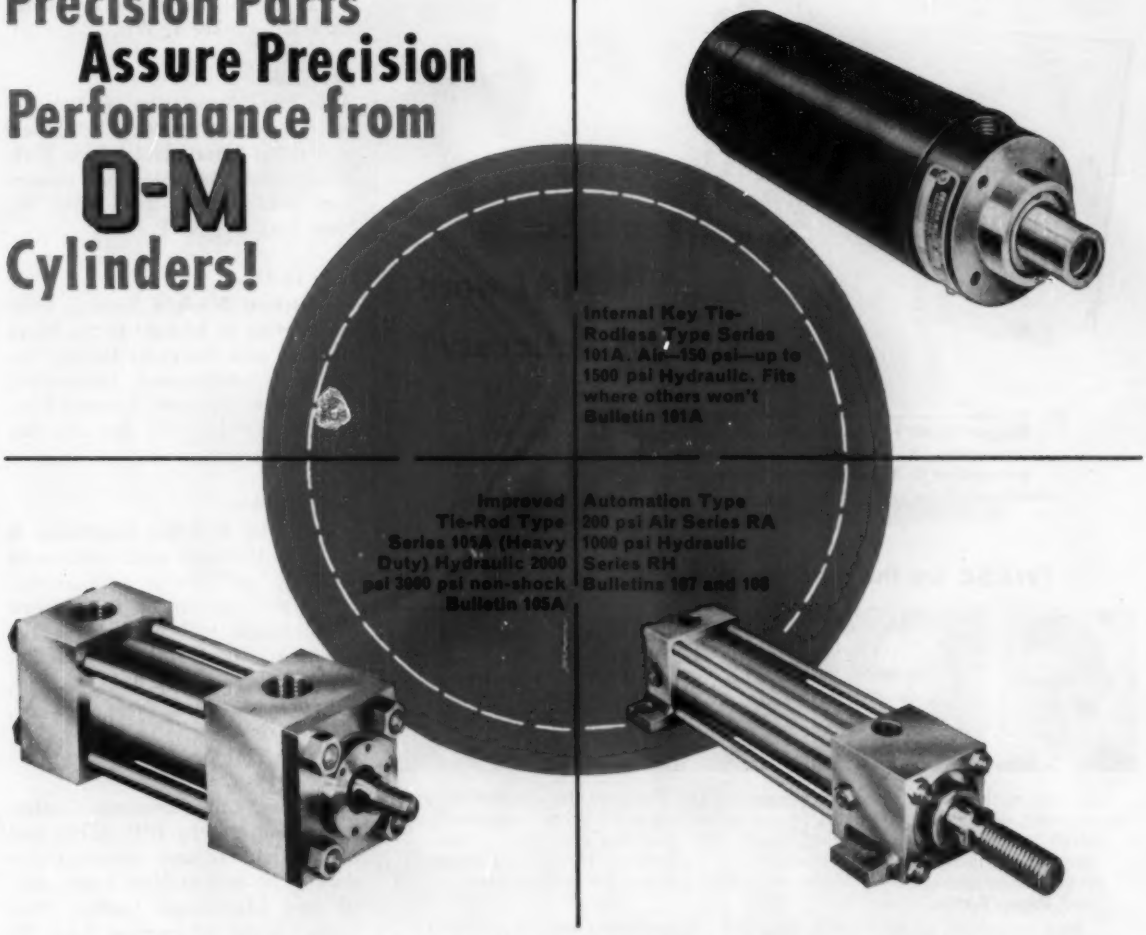
Dec. 4-7—

American Institute of Chemical Engineers. Annual meeting to be held at Statler Hotel, Washington. Additional information from society headquarters, 25 West 45th St., New York 36, N. Y.

Dec.7—

Seminar on Electro Hydraulic Servo Systems. Co-sponsored by the Milwaukee School of Engineering and the Milwaukee Chapter, Fluid Power Society. The sessions will be held at the school's Hall of Science. Additional information

Precision Parts Assure Precision Performance from O-M Cylinders!


Internal Key Tie-Rodless Type Series 101A. Air—150 psi—up to 1500 psi Hydraulic. Fits where others won't Bulletin 101A
Improved Tie-Rod Type Series 105A (Heavy Duty) Hydraulic 2000 psi 3000 psi non-shock Bulletin 105A
Automation Type 200 psi Air Series RA 1000 psi Hydraulic Series RH Bulletins 107 and 108

ALL O-M CYLINDERS MEET JIC STANDARDS

With all matching parts and mounts machined to close tolerances, O-M Air and Hydraulic Cylinders eliminate misalignment friction, unnecessary wear on rod, bearings and packings, also reduce maintenance, when operated singly or in sequence under automatic cycling. The length and direction of piston rod travel is accurately controlled whether the job calls for moving a machine member, holding a tool, positioning, clamping, releasing a work piece, activating an indexing table or other applications. In addition, precise cushioning against piston shock on thrust and return strokes makes for smoother, dependable operation.

O-M Cylinders are available in a complete range of sizes (1½" to 8" bores) with standard or heavy-duty rods. Complete line of interchangeable parts and mounts. Immediate delivery on most sizes.

If you are designing air or hydraulic cylinders into original equipment for precision control of linear motion, coupon below will bring our latest bulletins showing construction and dimensional details, engineering drawings, capacity chart and mounting data. For your copies, **MAIL COUPON TODAY.**

ORTMAN-MILLER MACHINE COMPANY
25 143rd Street, Hammond, Indiana

- ☐ Have representative call

Send Bulletins

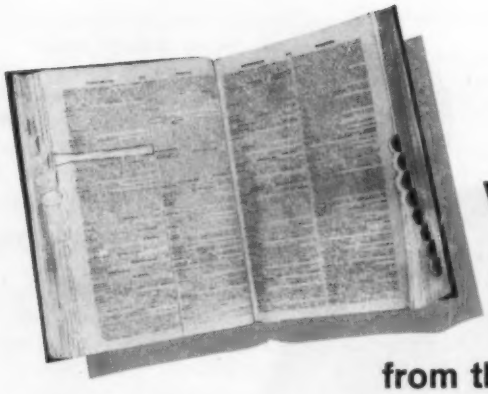
- ☐ 101A
- ☐ 105A
- ☐ 107
- ☐ 108

NAME_____ POSITION_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____



WHO cut out WHAT word from the dictionary?

im-pos"si-bil'i-ty, *n.* [-TIES, *pl.*] **1.** The fact or state of being impossible. **2.** That which is impossible; something that can not exist or be done.—**im-pos'si-bly,** *adv.*

THESE are the men who cut it out:

. . . part of the staff of Automation Engineering Laboratory, Incorporated . . . engineers, designers, inventors . . . yes, even dreamers. They have consistently solved "unsolvable" manufacturing, handling or processing problems . . . have designed and built "impossible" machines . . . that worked! They have done this for companies among the top five in such varied fields as Automotive, Electrical, Food, Paper, Textiles . . . etc.

Most important: in developing, designing and producing new or improved machines, processes and automated systems for industry, Automation Engineering Laboratory *has virtually eliminated costly risks of clients' capital!* How? By AEL's new concept of "STEP-BY-STEP Automation"®.

WHAT IS IT?

Briefly . . . it is AEL's systematic, step-by-step approach to creating equipment and processes. It involves *proving out* planned functions on working models . . . *one step at a time.* Function "A" is contracted for, completely proved out and demonstrated to you before Function "B" is even attempted . . . and so on. *Thus you will see your project operating in prototype within the first 15% of your total expenditure.* And, when your machine or system is completed, *it will work exactly as it should!* This is automation that any manufacturer can afford.

NOW...ABOUT YOUR PRESENT PROBLEMS

Whatever your automation problem, may we suggest you write or phone us? One of us will visit you . . . listen carefully to your problem . . . gather information. After studying your over-all layout, he will go back to Stamford and share your problem with other AEL Senior Staff Members. What he will then tell you is *"We can do it!"* and . . . on a contract basis you will appreciate. Remember, the word "impossibility" has been cut out of our dictionary. Try us.

AUTOMATION ENGINEERING LABORATORY
INCORPORATED

● **AEL Development and Research Division, Inc.**
AEL Manufacturing Division, Inc.
AEL Food Machinery Division, Inc.

84 Commerce Road • Stamford, Connecticut

from Mr. Mel Streigel, Milwaukee School of Engineering, Technology Park, Milwaukee 1, Wis.

Dec. 7-9—

National Association of Manufacturers. Annual meeting to be held at Waldorf-Astoria Hotel, New York. Information available from association headquarters, 2 E. 48th St., New York 17, N. Y.

Dec. 12-14—

American Nuclear Society. Winter meeting to be held in the Mark Hopkins and Fairmont Hotels, San Francisco. Additional information from Dr. E. Zebroski, General Electric Co., APED, P. O. Box 254, San Jose, Calif.

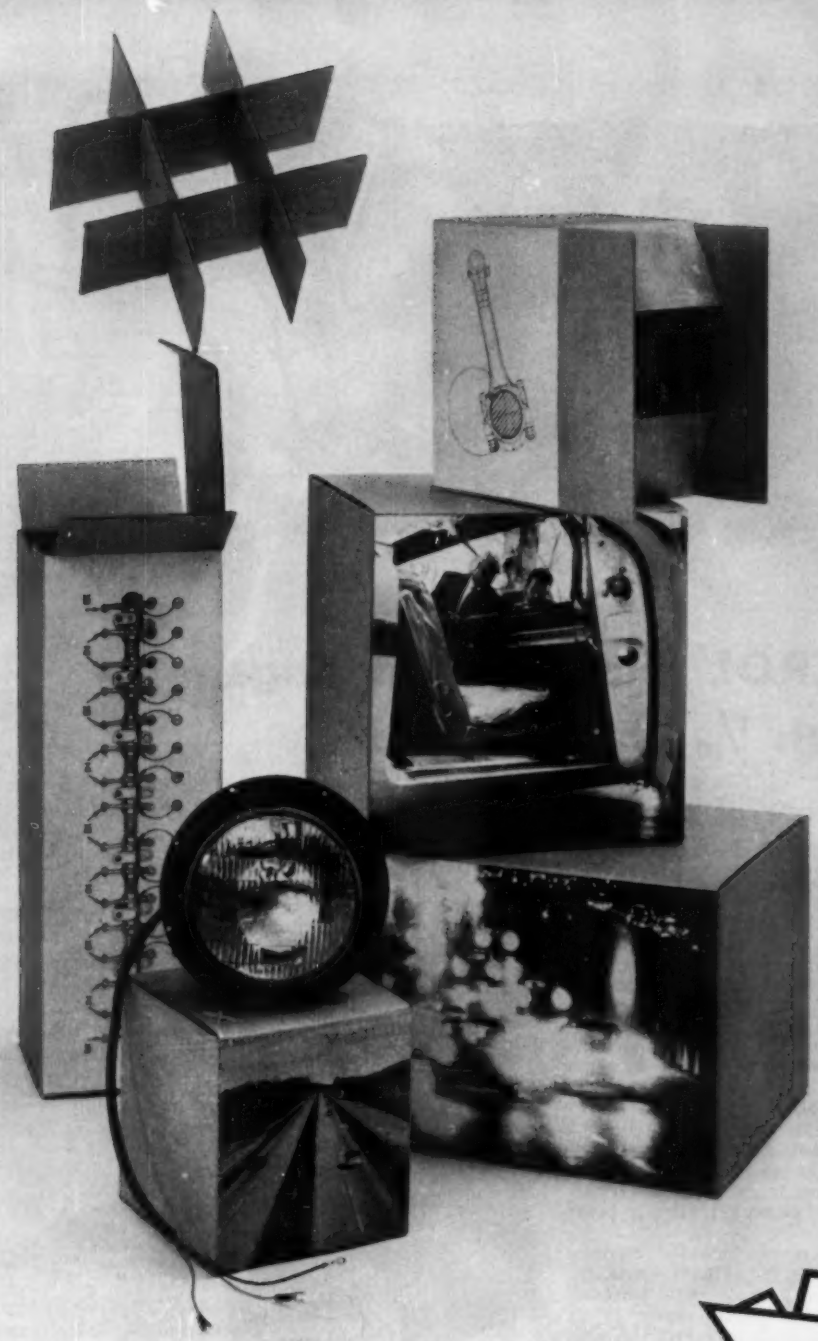
Dec. 12-15—

Industrial Building Exposition & Congress. Exhibits and conferences featuring methods as well as materials and equipment for efficient plant design will be held at the Coliseum, New York. Information available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Dec. 13-15—

Eastern Joint Computer Conference. Sponsored by IRE, AIEE, and ACM. Exhibits and technical sessions to be held at New Yorker Hotel and Manhattan Center, New York. More information from El-

ELECTRONIC control system developed by Leeds & Northrup Co. provides all the required instrumentation to measure and control a furnace. Instruments used in the system include a temperature transmitter, single-pen recorder, controller, set-point unit, auto-manual station, and a magnetic amplifier. The system features flexibility in operation with provision for integrating data-handling and computing equipment.



Miles of automotive products

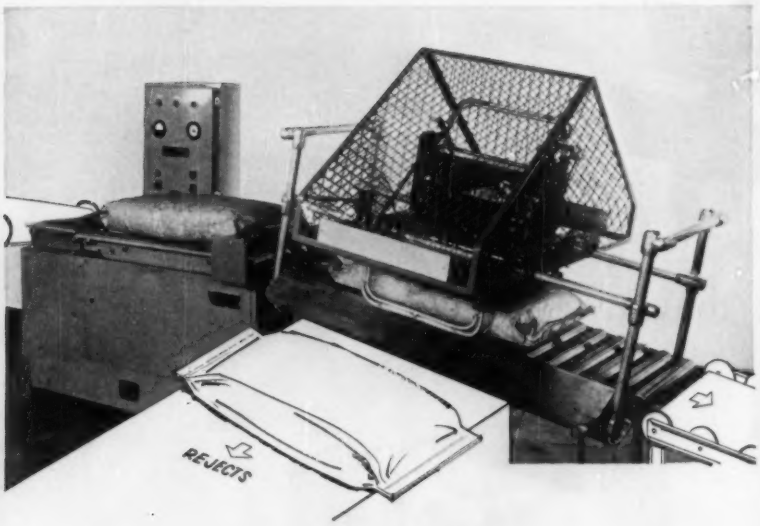
Millions of shock absorbers, spark plugs, headlights, seat covers; thousands of windshields and grills... a bumper-to-bumper crop of automotive products is shipped in Hinde & Dauch Division corrugated boxes. Hinde & Dauch is a major supplier to leading companies in this great industry ... a reliable source of *boxes in volume at competitive prices.* Call the Hinde & Dauch Division plant nearest you.

West Virginia Pulp and Paper

Hinde & Dauch Division

17 Plants • 42 Sales Offices • Sandusky, Ohio

Circle 671 on Page 19



SELECTROL® checkweighs bags with 1/10 of 1% accuracy

...with rate of speed at twenty 50-pound bags per minute...

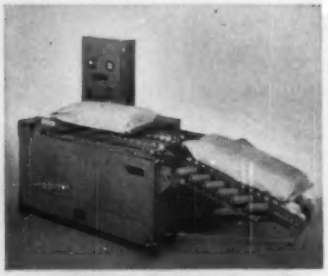
Model 1250 Selectrol, designed for installation in a production line, checkweighs bags from 25 to 150 pounds in motion... and detects weight variations as small as 1½ ounces or less per 100 pounds. Speed is variable—up to 25 bags per minute, depending on size and weight. Tolerance is adjustable to your requirements.

The Selectrol shown above has automatic overweight and underweight rejection mechanism. Models are available with underweight rejection only or without rejection mechanism. All electrical parts are fully protected against dust and oil.

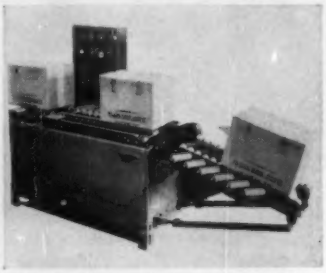
Optional equipment includes: recorders, counters, visual and audible signaling devices and special control accessories to your requirements.

Selectrols are made by Exact Weight, a leading manufacturer of job-engineered scales for 45 years with experience gained through hundreds of checkweighing installations.

WRITE FOR BULLETIN 3376



Selectrol Bag Checkweigher shown above without rejector mechanism



Selectrol Case and Carton Checkweigher with rejector mechanism. Acceptable weights continue in a straight line; over and under weight cartons are diverted off the line.

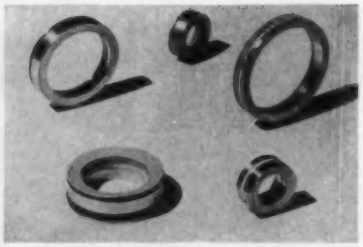
Exact Weight SCALES

THE EXACT WEIGHT SCALE CO.
907 W. FIFTH AVE., COLUMBUS 8, OHIO
In Canada: 5 Six Points Road, Toronto 18, Ont.

Find us in your local Yellow Pages

Sales and Service Coast to Coast

BETTER QUALITY CONTROL...BETTER COST CONTROL



SPRING-LOADED, self-conforming polymer seal introduced by Del Mfg. Div., Arrowhead & Puritas Waters Inc., combines polymer and spring steel in a principle ensuring efficient operation over a temperature range of −320 to +500 F, under pressures up to 10,000 psi. The seal, available in various sizes, is suitable for applications in reciprocating and low-speed rotary shafts under high pressure liquid and gas conditions. Seated around a shaft, the seal sets up a load toward the shaft, its polymer gasket deforming under constant pressure to produce a gas-tight seal. The unit is self-adjusting to creep and wear.

---

mer Kubie, Computer Usage Co., 18 E. 41st St., New York 17, N. Y.

Jan. 9-11—

Symposium on Reliability and Quality Control. Seventh national symposium sponsored by IRE, AIEE, EIA, and ASQC. To be held at Bellevue - Stratford Hotel, Philadelphia. Additional information from R. E. Kuehn, Institute for Defense Analysis, Pentagon, Washington, D. C.

Jan. 9-13—

Society of Automotive Engineers. Annual meeting to be held Cobo Hall, Detroit. More information from society headquarters, 485 Lexington Ave., New York 17, N. Y.

"But, Sam, we had to automate—bench methods just won't supply the demand anymore."

Automatic marking of hot steel . . .

Controls by ALLEN-BRADLEY, of course

Here's an interesting job that's gone "push button"—stamping heat numbers on hot steel! Now, from a remote console, the operator automatically sets numbers on the marking head and propels it against the steel. The controls, *of course*, are Allen-Bradley because they provide the continuous reliability that is essential to this production.

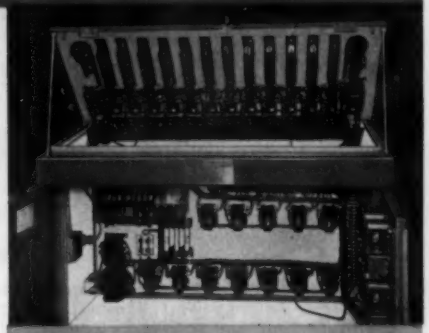
The simple, ONE moving part solenoid design of A-B starters and relays assures millions of trouble free operations. And the double break, silver contacts—used on all A-B control—eliminate costly downtime for maintenance. Keep your production lines rolling . . . insist on Allen-Bradley *quality* motor control. You cannot do better!

Allen-Bradley Co., 1339 S. First St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY

Member of NEMA

Quality Motor Control



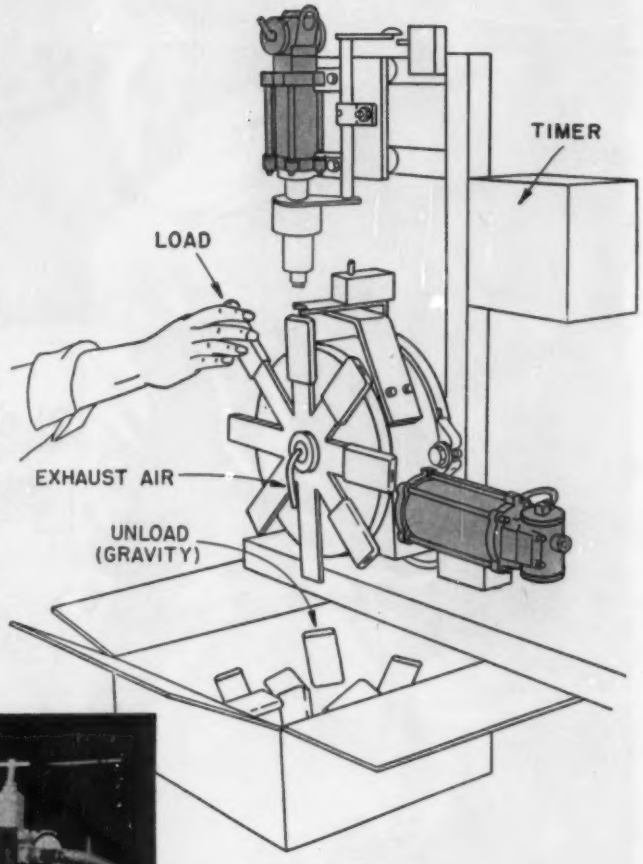
The relays and push buttons used in the remote control console of this M. E. Cunningham Marking Machine are all standard Allen-Bradley catalog items.

THIS SIMPLE SHOP-BUILT "FERRIS-WHEEL" CAN BE USED TO PUNCH, STAMP, HEAT-SEAL . . . OR TO FLARE, FORM OR RIVET

It's another example how versatile Bellows "Controlled-Air-Power" Devices can be used to "spot-automate" operations in almost any industry. This "SPOT-A-MATION IDEA" is based on a setup used by Frank Steere Enterprises to cut a slot in a plastic key case. But the basic idea can be adapted to perform a host of operations in wood, leather, light metals, or plastics.

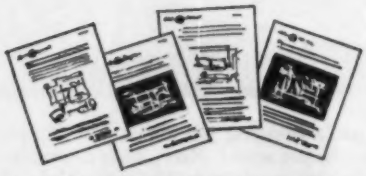
It's a simple, inexpensive device. A Bellows Rotary Feed Table, mounted vertically, feeds the part to the tool attached to the piston rod of the Bellows Air Motor. The two are electrically interlocked. Bellows Rotary Feed Tables can be provided to index almost any number of positions. The unit can be equipped with a "timed dwell"; additional work stations can be set up to perform other operations on the same part; automatic feeding or ejecting devices could be installed.

Whatever you make, however you make it, Bellows "Controlled-Air-Power" Devices can help you make it at lower cost.



In this application a heated Slotting Tool is used, hence the Bellows BT-1 Timer to control the length of time the tool is in contact with the plastic part. The exhaust air from the Rotary Feed Table is used to give an assist in unloading the part.

THIS SPOT-A-MATION IDEA FILE IS YOURS ON REQUEST



Complete wiring diagrams, installation data and equipment list on the "ferris-wheel" shown, and on a score of other applications where Bellows air-powered work units are used to convert existing equipment to lower cost operation. Write for it today. Address: Dept. AU-1260, Bellows-Valvair, Akron 9, Ohio.

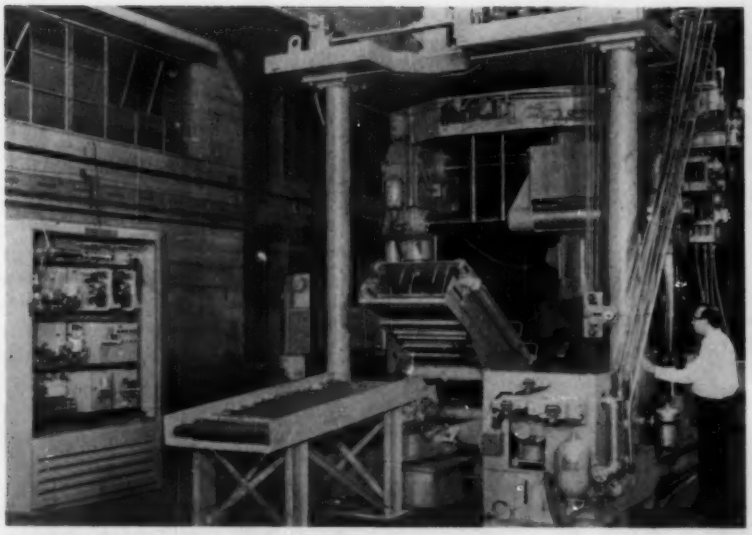
13148-3

Bellows-Valvair

AKRON 9, OHIO

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

Circle 674 on Page 19



Port Kembla, Australia—Continuous vertical casting machine for copper billets, bars, or slabs has been shipped to the Electrolytic Refining & Smelting Co. of Australia by Loma Machine Mfg. Co. Inc., New York. Production capacity of the machine can be varied from 3 tons per hour of 3-inch billets to 10 tons per hour of 5½ by 33-inch slabs. The graphite-lined molds are located on top of the machine and are fed liquid metal from drum-type induction melting and holding furnaces. As the metal solidifies, the casting descends and is continuously withdrawn from the mold by a double set of pinch rolls. It is received in a vertical discharge basket and cut to length by a flying circular cut-off saw mounted on a traveling carriage. The basket then rotates automatically to a horizontal position and discharges the 30 to 72-inch long casting to a roller conveyor.

Behind the Curtain

IN A RECENT talk delivered at the 59th Annual Meeting of the National Machine Tool Builders Association, Forrest D. Hockersmith, director, Export Policy Staff, U. S. Department of Commerce, made the following observations concerning the status of the machine tool industry in the Soviet Union.

Hockersmith stated that at the present time Soviet machine tools are being produced by some 170 plants. It is estimated that 50 plants specialize in metalcutting machines, 10 in metalforming machines, and the remainder produce machine tools and other machinery.

In addition to standard types of machine tools, the Soviets have built many prototypes of numerically controlled machine tools, including lathes, mills, drills, horizontal and vertical boring mills, and jig borers. The functions performed by this equipment consist of automatic positioning and 2 or 3-axis duplicating. Open and closed loop control circuits are used, and these are actuated by punched tape, punched cards, or magnetic tape.

In the area of electrical machining, the Soviets have advanced rapidly, building 95 units in 1958, 200 in 1959, and expecting to build 400 units in 1960. The majority of metalforming machine tools built are general purpose presses (mostly mechanical), hammers, shears, and bending machines. More sophisticated types such as spin forming, stretch wrap forming, and others, are built but are just emerging from the prototype stage.

Hockersmith said that the quality of Soviet machine tools varies considerably when compared by Western standards. Technological advancement varies from obsolete to highly advanced types, and workmanship varies from poor to very good. Materials are good, and design is functionally adequate. Almost all Soviet models, however, are underpowered when compared to U. S. machines of similar size.

The Soviets have attained a high rate of machine tool output by using a high degree of standardization of components which are common to many sizes of the same type of machines. Standards have been applied to 85 per cent of the general purpose metalcutting tools and 75 per cent of the general purpose press and forge machine tools. This has enabled the Soviets to use mass production techniques, such as conveyor lines, for machining of parts and components and for the assembly of finished machines.

The largest Soviet machine tool builder, the Moscow "Krasnyy Proletariy" plant, produces more than 12,000 16-inch engine lathes a year by using conveyor line methods for the production of bases, beds, headstocks, and gears and by assembling the machine tools on a moving conveyor. Using similar methods, the Odessa Radial Drill plant has been producing over 2000 drills a year

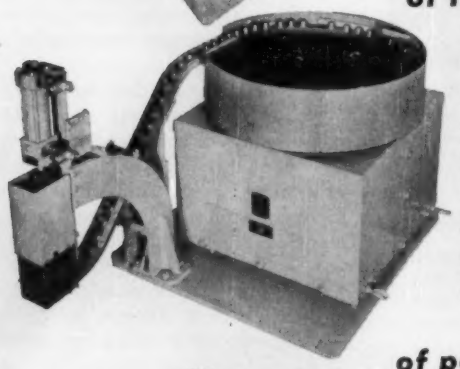
THE CARE AND FEEDING

of parts discharged at high or low heights

DPS ELEVATING FEEDERS elevate, orient and feed parts of almost any size, shape and material to other machinery for processing and assembly. High capacity storage bins are designed to assure a steady flow of parts to elevating mechanism regardless of load level.

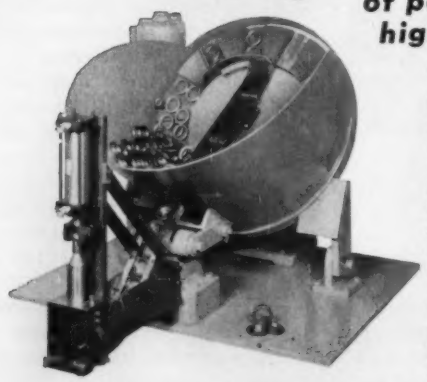
Orientation of parts is accomplished at discharge point of elevator — simplifying external track construction. Feeder can be arranged for right- or left-hand discharge. Return chutes are cushioned.

New Bulletin 2812 has full data on DPS elevating feeders. Write for your copy today.



of fragile or finished parts

DPS VIBRATORY FEEDERS are bowl type units that gently handle parts too light or fragile to be handled in rotary type feeders. Through a simple electromagnetic drive, a vibrating action is transmitted to the bowl causing the parts to move up a circular, inclined track. The oriented parts then enter feed tube or discharge track to machining or assembly areas.



of parts for high-production assembly

DPS ROTARY FEEDERS employ radially slotted or grooved rotating collector rings. Efficient orienting and feeding of parts is achieved through proper design and engineering of baffle plate, selector guard, feed track, and escapement mechanism. Three different designs are available to meet holding, orienting and feeding requirements. Safety clutch prevents damage to motor or gears in the event of parts jamming.

Detroit Power Screwdriver Company offers industry's most complete line of selective feeders . . . ranging in holding area from 80 cu. in. to 20 cu. ft. For complete details, call your DPS representative or write direct. *Ask for free catalogs!* 15,335

DETROIT POWER SCREWDRIVER COMPANY
2811 W. Fort St. • Detroit 16, Michigan
A Subsidiary of Link-Belt Company

since 1956. Other plants building engine lathes, milling machines, and upright drills use similar methods but not as extensively as the plants mentioned. The various types of metalforming machine tools are produced in relatively small quantities by conventional methods.

Hockersmith pointed out that Soviet goals for the machine tool industry call for the production of up to 200,000 metalcutting and 36,-200 metalforming machine tools per year in 1965. This includes 38,000 specialized and special purpose machine tools. By 1965, the number of type-sizes of metalcutting machine tools in production will be increased to 1500. Fifty types of numerically controlled machine tools are to be produced by this time, and 1300 automatic lines are to be installed in engineering industries. The Soviets expect to achieve an inventory of 2.5 million machine tools by 1965 which compares with a current inventory of approximately 2 million.

Hockersmith stated that progress made to date by the machine tool industry indicates that the Soviets will achieve the major share of their plans by 1965. Important factors which will contribute to achievement of these plans include a high degree of standardization in the industry, specialization of production in many plants, use of conveyors, and the extensive research facilities available. The industry will probably be unable to produce the number of automatic lines planned. It appears that Soviet plans for installation of 1300 lines include units which are to be imported. This has been indicated by Soviet inquiries and orders for this type of equipment from the West.

London, England

Orders on hand for 22 digital computers in both home and foreign markets (including the U. S.) are reported by Elliot-Automation Ltd., London. Greatest activity is in the field of computers for control of industrial processes in the electrical power, gas, chemical, nuclear, and steel industries. The market for the company's business data processing computer is also reported brisk. A new computer with a 5 millimicrosecond switching time is expected to find wide use for high-speed scientific computations.

7½ hp Ajusto-Spede Drive

Common motor-drive housing for units up to 7½ hp saves space — can be foot- or flange-mounted. Larger sizes up to 100 hp with individual motor and drive housings mounted integrally.

The Louis Allis AJUSTO-SPEDE® drive is more compact, precise, and trouble-free

Here's an adjustable speed drive that allows *truly precise* machine operation. Speed regulation is automatic and stepless — results in faster, more efficient production at lower cost, with less waste, and minimum wear on equipment.

These and other benefits are yours when you use the improved Louis Allis Ajusto-Spede drive. For example, it can be set before or during operation to deliver any desired speed within its range. Its *exclusive* tachometer feedback circuit monitors the output speed and *automatically corrects speed and holds it* regardless of load changes.

This improved drive requires minimum maintenance. Its stationary field has no brushes, commutators, or slip rings to cause trouble. The source of power is an equally trouble-free standard a-c squirrel cage motor.

®Ajusto-Spede is a registered trademark of the Eaton Mfg. Co.

The cast-iron housing keeps out dirt, chips, and moisture — resists corrosion.

The compact Ajusto-Spede also saves space. Integrally-mounted motor and drive simplify handling — can be easily adapted for installation on new or existing machines. Controls can be mounted at the machine or any other convenient position.

The Louis Allis Ajusto-Spede drive is the practical solution to almost every application that requires dependable, easily controlled adjustable speed. It is the answer to precise operating speeds for machine tools, process machinery, test equipment, windups, conveyors, printing presses, and other equipment. Contact your Louis Allis District Office for information and application help. Or write for bulletins 2750 and 2800 — The Louis Allis Co., 463 E. Stewart St. Milwaukee 1, Wis.

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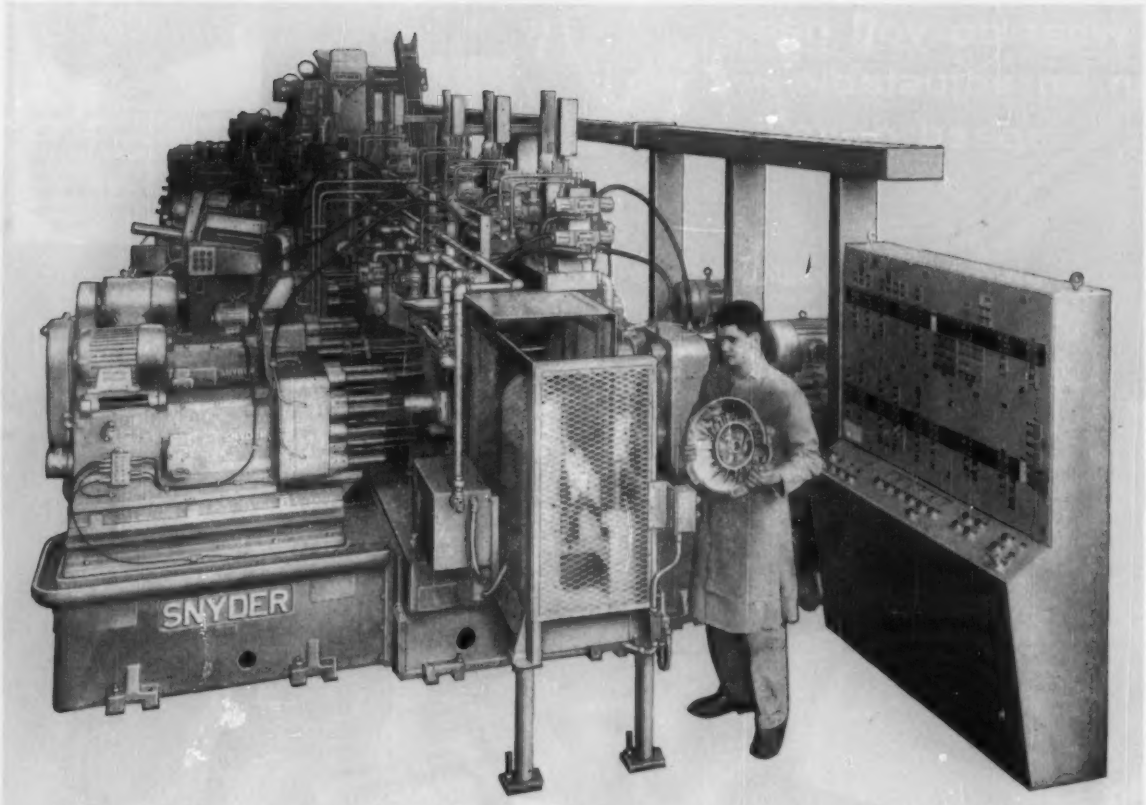
LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

AS-329



DIFFERENT SIZED PARTS INTERMIXED AT RANDOM ARE PROCESSED AUTOMATICALLY ON SNYDER SPECIAL 56-STATION TRANSFER

Here's another big Snyder special "building-block" transfer with a bit of extra versatility.

Specifications called for one sequence of operations on a big aluminum transmission cover case for domestic use and a different sequence on a smaller cover for export.

Schedules set a production rate of about four domestic units to one export unit but, for production convenience, the machine had to accept these parts intermixed at random and run them through automatically.

So, Snyder Engineering designed a "collar" which bolts to the smaller piece, bringing it up to locating and clamping dimensions of the larger piece. Lugs on the collar and workpiece control appropriate switches which by-pass certain operations. Parts are automatically positioned in process.

Operations include drilling, reaming, boring, tapping, chamfering, spotfacing, center holing, end milling, probing, air gaging, pressing in rectangular plug, pressing in bushing and a couple of washing operations.

Production is 150 parts an hour at 100% efficiency. Any of the 20 segments can easily be converted for comparable operations on other parts and the number of segments can be increased or reduced at any time. Your inquiries are invited.

SNYDER
CORPORATION
(Formerly Snyder Tool & Engineering Company)

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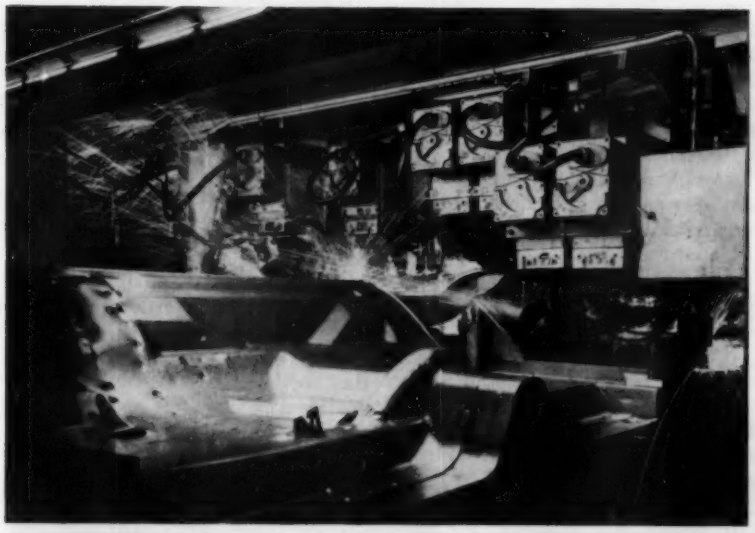
By JAMES C. KEEBLER Managing Editor



Floor pan assembly in last welding press in an automated line at Chrysler's Twinsburg, Ohio stamping plant gets final welds that make total of 857 spot-welds in assembly for unitized body.

Co-ordinating Welding

COMMUNICATION is recognized as one of the largest problems in industrial organizations. With the increasing complexities of corporate activities, there are mounting needs to keep the left hand better informed about the activities of the right hand.

Strive Together

Automaters have recognized the benefits of improved communications between the various departments of the corporation and strive constantly to achieve good liaison between those who design the product, those who build it, and those who specify the processes and equipment on which it is built. This co-ordination is required by the fact that the present model will be replaced by a new design and the experience gained in manufacture is a valuable ingredient in devising a production system that solves the new fabrication problems of the new design.

Hang Together

In a like manner co-ordination of production equipment in automated installations has assumed increased importance as the complexities of the equipment have grown. A single station automatic cycling machine may require only that the tool slide and the clamping device be interlocked to function in unison, whereas the automated line requires that many workstations and handling equipment sequence in a prescribed manner and be interlocked to perform together, as if they were all one machine.

Just as the pirate band had to hang together or be hanged separately, the effective interlocking of all stations on the automated line is necessary if each is to be able to do its work properly.

Welded Pans

An example of a sophisticated control system for automated welding machines is to be found at Chrysler's stamping plant at Twinsburg, Ohio. This plant is the newest and largest of the group's plants and, in addition to a multitude of stamping operations, houses their biggest automatic welding assembly lines. Two lines, 658 feet in total length consist of 24 machines that produce floor pan assemblies held together by 857 welds.

The assembly consists of inner and outer rail members welded to crosspieces to form a ladder assembly onto which is welded a skin weldment of center floor pan and rear floor pan. These details and an assortment of brackets and straps make an assembly weighing 183 pounds and measuring 102 inches long by 65 inches wide.

Production schedules require that the equipment be such that it can be quickly reset to accommodate 7 styles of pans for autos having 3 different wheelbase dimensions.

Automated Line

On separate branches of a line the ladder and skin subassemblies are each put together in welding presses linked by shuttle type transfer equipment. At the junction of the branches the skin is placed on the ladder and proceeds through a line of four giant press welders to get the remaining welds that make the final assembly solid.

At various stations along the line some component parts are positioned manually into place before the welding press closes, at others the parts are mechanically positioned. In all cases the large assemblies are transferred by reciprocating shuttle bars that remove them from one workstation and deposit them in the next. At the end of the line the completed weldments are elevated into a vertical position and picked up by carriers

on a Link-Belt power-and-free overhead rail conveyor system that takes them through an area where operators with Airco gun spot arc welders hit spots required to assure top quality. The power-and-free system takes the pan assemblies to a loading station where groups of twelve are accumulated on a special section that lowers them onto pallet racks that are moved by lift trucks into railroad boxcars for shipment to assembly plants.

Welding Machines

Resistance spot welding heads are mostly mounted in the stationary top platen of the welding presses. Some must necessarily be in the lower platen that reciprocates up and down to open and close a press. After a transfer shuttle retracts from depositing a pan in a press, the part is raised up to meet the electrodes. Electronic timers for each machine time the squeeze, weld, and the holding under pressure until the molten metal solidifies.

Integrated controls synchronize the welders in each branch of the T-shaped line with the hydraulically operated transfer equipment in that branch. To minimize the time between cycles of the transfer bars it is appropriate that all welders in a branch fire at once. However, because the whole installation is so huge (it is rated at 45 million watts) the simultaneous firing of banks of welders would be accompanied by an excessive voltage drop that would seriously effect weld quality. To avoid this possibility Chrysler has installed a welder interlock control that uses an electronic scanner to travel from one machine to another, such that 320 times a second it checks each unit to see if it is ready to weld. When the machine circuits are ready this scanning interlock control permits individual firing of the 24 units so fast that the human eye cannot detect the intervals on an indicating light panel. Production rate makes 2000 pans per shift.

If trouble develops in a given machine and it fails to fire and send back a "finish" signal within a three-second interval, the scanner turns on a red warning light and moves on to fire other welding machines.

If, in the case of single line operation, the trouble spot cannot be repaired in a few minutes, production can be shifted to the other line and the scanner will control it in the same manner.

If tube trouble or other malfunction should occur in the welder interlock control there is a standby unit wired-in such that it can be placed into service by simply turning a selector switch knob.

To provide power for all this welding and co-ordinating, the Chrysler Corp. owns and operates its own outdoor sub-station which steps power down from 132,000 volts to 13,200 volts for distribution through tunnels to various sub-stations throughout the plant.

There are three and a half miles of armored coaxial cable and conductor cable feeding the power to these automated assembly lines. There are more than 10 miles of control wires in the operation. The maintenance of top quality production depends to no small degree on the proper functioning of the power and control systems that serve the welders. Consistent welding quality depends upon each welding machine receiving the same charge of electricity each time it welds.

Engineering Co-ordination

In reviewing this installation one is impressed by the magnitude of the job of co-ordination required to plan, design, build and install such a production facility. Chrysler's manufacturing engineers on the division staff first planned the process and recommended the sequence steps and machines. The plant's mastermechanic's office further developed the plan and contributed thinking as to design layout, equipment features, and tooling details. Plant Engineering personnel devised the plant layout, co-ordinated engineering of the conveyor system and supervised installation of the lines.

Welding presses were procured from Danly; welder controls from Weldtronic; welders, fixtures, and transfer devices from Resistance Welder; and the welder interlock control from Instrument Control Co.

Engineering co-ordination of all suppliers involved a systems engineering approach by Chrysler engineers. Designs of each segment had to be checked and approved, plant preparations made for arrival of equipment, and engineering tryouts made prior to getting into full production.

Such effort is required to be competitive in today's automobile manufacturing world.

View of discharge side of welding press at end of automated assembly line at Chrysler Twinsburg. Assemblies are automatically tipped up to the left and picked up by carrier on power and free conveyor system.

PIN POINT PROGRAMMING

AMP PINBOARDS can do a host of dry circuit switching or commoning functions . . . permit numerous matrixes in one assembly. Complicated switching functions can be accomplished by simply inserting or removing a pin.

You can use these PINBOARDS as modular building blocks for instrumentation applications, automated tooling, test equipment, data processing . . . any variety of size and grid arrangements in multiples of a basic 15 x 5 hole pattern. Contact springs can be bussed in any combination desired. And for safety, there are no exposed conducting surfaces on the rear side of the board. The conducting area of the pin is safely inside board before contact is made with mating springs.

AMP PINBOARDS are factory pre-wired to your specifications . . . with standard or special silk screen legends. Designed for simplicity . . . flexibility . . . reliability . . . with three amperes continuous current rating.

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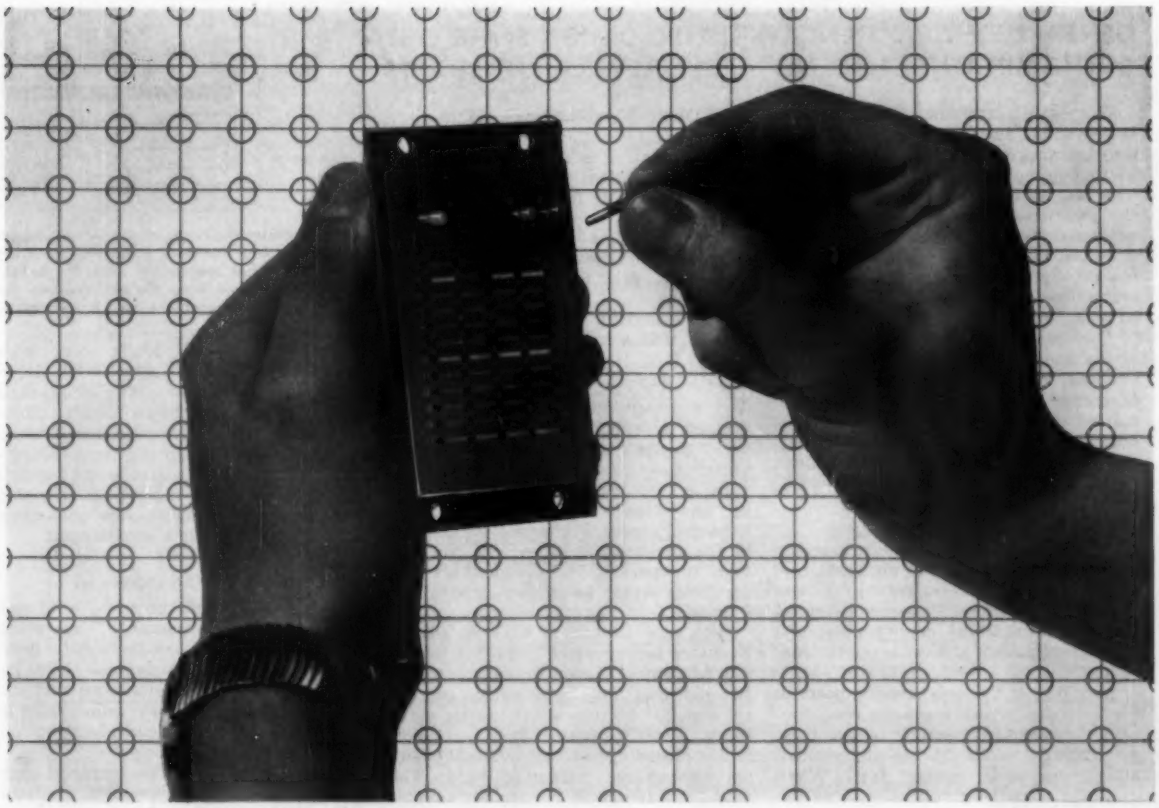

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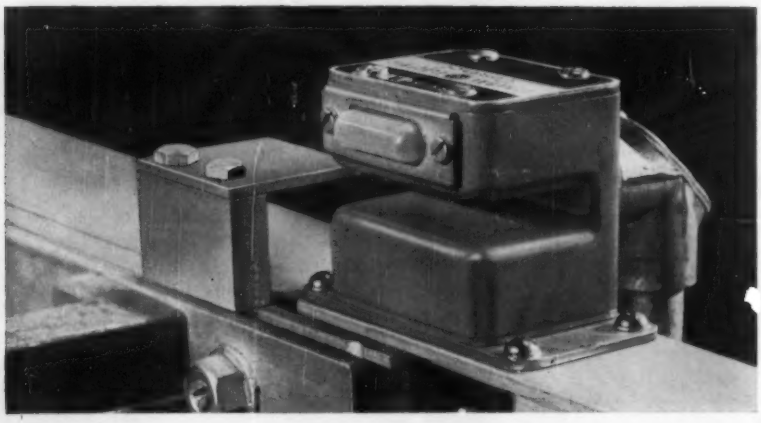
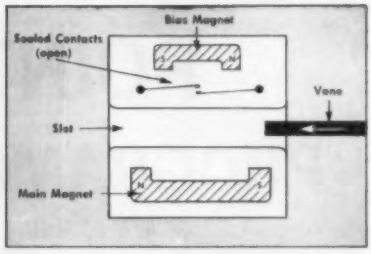
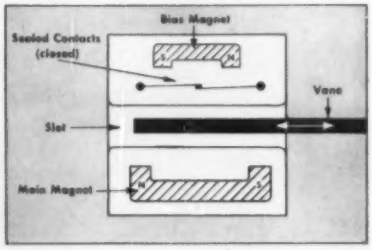
NEW vane-operated limit switch helps industry solve major electrical problem: limit switch life





On normally open form, bias and main magnet flux are balanced at the switch, causing it to remain open. As vane enters the slot, flux of the main magnet is shunted to the lower reluctance path offered by the magnetic material in the vane.



As vane passes the center of the switch, enough flux shunts from the main magnet to cause the flux of the bias magnet to close the switch. Withdrawing vane from the slot reverses the conditions and causes the switch to reopen.

GENERAL ELECTRIC'S ENCAPSULATED DESIGN SEALS OUT CONTAMINANTS; HAS NO ARMS, LEVERS, OR SHAFTS

General Electric's new vane-operated limit switch design surmounts most of the operating problems that cause failure in today's conventional limit switches. The unique new limit switch performs the position-detection function of conventional switches and *eliminates physical contact with the moving object.* It has no shafts or arms to fail, no sliding or rotating parts to wear, no shaft seals to leak.

This means that the operating life of the vane-operated limit switch is not affected by such tough application requirements as frequent operation; hammering of lever arms and mechanisms; lever arm "snapback"; mechanical wear; and splashing and spraying of coolants, lubricants, and other contaminants.

REASONS FOR LONGER LIFE

Contributing to the extremely long life of the new device is the encapsulation of all internal components in a cast aluminum enclosure. This means liquids, dirt, or metal chips cannot enter the switch mechanism and cause operational failure.

In addition, the only moving parts in the new design are magnetic reed contacts hermetically sealed in an inert gas. Thus, switch life is determined almost solely by contact load. When used with small a-c relays, such as the G-E CR2790 general purpose type, the expected operating life of the switch is from 30 to 50 million operations. It is capable of over 250 million operations when operating General Electric static control circuits.

The inherently longer life of the new vane-operated limit switch results in savings from greatly reduced maintenance and replacement expense and less downtime. And the new switch costs about two-thirds less than proximity switches, making it only slightly higher in price than a conventional limit switch.

HOW IT WORKS

The vane-operated limit switch is energized by passage of a separate steel vane through a recessed slot in the switch (see illustrations at right). The vane is attached to the mechanism to be controlled. As the vane passes through the slot, it changes the balance of the magnetic field, causing the contacts to operate. The contacts are hermetically sealed in an inert gas to prolong life.

The new switch is easy to install. Front- or top-operated forms are available to control linear or rotary travel. In addition, the base plate can be rotated 90° to provide mounting flexibility. Both normally open and normally closed forms are available with or without an indicating light. The new limit switch is 25 percent smaller than previous models, and it requires no separate power supply or amplifier.

The switch can detect very high speeds of vane travel without detrimental effects such as arm or mechanism wear or breakage. The switch also offers excellent accuracy and response time. Providing the path of the vane through the slot is constant, trip point repeatability is constant within plus or minus 0.0025 inch. The switch response time is approximately one millisecond.

MEASURABLE ADVANTAGES

Vane-operated limit switches hold significant and measurable operating advantages over conventional limit switches. These advantages can be measured by the maintenance and replacement savings they can produce, and deserve serious consideration on limit switch applications.

For more information contact your G-E sales office or request bulletin GEA-6995 from General Electric Company, Schenectady, N. Y. 811-8

GENERAL ELECTRIC

You get
MEASURABLE ADVANTAGES
with General Electric control.

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Production R&D

Though we are only on the threshold of the decade, there are already many who are deeply disappointed that the predicted soaring markets have not appeared overnight. Sights set on quick and easy manufacturing successes, have in many cases, obscured the path necessary for building gradually and soundly for the long pull.

In a recent talk to the Society of the Plastics Industry entitled "The Competitive Sixties," David H. Dawson, vice president of E. I. du Pont de Nemours & Co., has placed the issue squarely to manufacturing management:

"I would like to observe the importance . . . of building a sound financial structure, capable of adapting itself to the rapid technological changes which are probably coming. These may well be expected to face you with rapid obsolescence of equipment and machines. That, too, is good, but if prepared for only by the meager depreciation allowance of the tax laws, it may present some rather acute problems of financing future changes. Whether tax-deductible or not, the technical obsolescence of plant and machinery is a cost of doing business which, if not provided for, will surely limit future growth.

"I should like to ask you to consider the need to maintain your own technical and development effort at a high level, and to increase this activity consonant with the growth and potential of your industry.

"In view of the extent to which research and development have shown signs of growing into the sacred cow of American industry, this may seem superfluous. But your industry is subjected to a very real danger in that you may be tempted to permit your suppliers to carry that burden. It has happened in other businesses, and usually not to their advantage. I have no doubt that others in the industry — suppliers and perhaps equipment manufacturers—would be willing to do so, certainly they mount large efforts along these lines now. So much the better for you—provided only that you do not allow them to substitute for your own technical efforts.

"Only you have the direct contact with your customers and the consequent knowledge of their needs and your opportunities; only you have the detailed knowledge and control of manufacturing costs; only you are in a position to bring technical effort to bear on the critical areas and expand your markets most effectively. To lean on your suppliers excessively is to sap the creativity of your industry, and in the end to relegate it to a routine operation which would seriously limit its profit-making capabilities."

The points are well made. They provide some fundamental rules that bear serious consideration in the competitive days ahead.

PUBLISHER-EDITOR

EVALUATING PROJECT ECONOMICS

Consider the economics of proposals to invest funds in prospective projects in the light of these basic questions. What is the cost of capital that will be needed? How can returns from a project be evaluated relative to the investment required? From a group of unrelated possible projects, which project promises to be the most profitable?

By **THOMAS C. STOUT**
Staff Member, Systems Engineering Dept., Engineering Div.
Arthur D. Little Inc., Cambridge, Mass.

and

JOHN W. WEBER
Staff Member, McKinsey & Co. Inc., Chicago, Ill.

THE VALUE of an automated system lies with its economic worth, contributory to which are judgments about such factors as how much it will cost to modify the system at some future time, what the penalty will be for operating it at less than its design capacity, and system maintenance costs. Before the economics of alternate systems can be compared, the operation to which a selected system will eventually be applied must be studied in its entirety—this includes the effect the newly automated segment of an operation will have on every aspect of the total operation.

It is easy to see, for example, that an automated warehouse could place stringent requirements on the packaging of both incoming and outgoing materials and could affect distribution systems outside the warehouse and the handling costs of those producing facilities which feed the warehouse. After the broad study has been made, the financial comparisons can begin, a specific system can be selected, and its economics can be compared with other, unrelated projects throughout the company.

Associated with any firm's ability to apply funds to a project is a certain cost that must be paid for those funds. This cost is in *interest payments* if some form of debt financing is used to obtain the funds; it is *guaranteed dividend payments* in the case of preferred stock; and it is *earnings per share* if the financing is obtained by a common stock issue and present stockholders' return is not to be diluted. If internally generated funds are used, there is an associated cost like an opportunity cost. Such funds can always be paid out as dividends to permit stockholders to invest in alternative investment opportunities—or the internally generated funds can be used to reduce the firm's present capital structure, a method which effects a savings in capital costs. It is axiomatic that the projects a successful company will accept for investment must at least return this cost of funds.

Any firm's cost of funds, commonly called its cost of capital, represents a minimum return figure below which no investment projects should be accepted. It is evident that the method of computing the rate of return for an investment project must produce a figure that is directly comparable with the cost-of-capital figure. Furthermore, some means of ranking alternative investments must be avail-

PROBLEM

Calculate cost of capital.

CONDITIONS

Policy of a given company dictates that the firm's capital structure approach the following mix: Debt to be the source of 30 per cent of capital; preferred stock 10 per cent; common stock 30 per cent; and surplus 30 per cent. The best estimate of future interest to be paid on debt of the firm is 5 per cent, and a 7 per cent yield on issue price is expected for preferred stock. Present market price for common stock of the company is $20 per share, and the latest earnings are $2 per share. This price-earnings ratio of 10 is expected to be typical of the firm's future equity market. Income-tax rate for the firm is 50 per cent.

SOLUTION

Cost of capital from debt: Interest payments are tax deductible. Therefore, the after-tax cost of debt is:

$$\text{Cost of Capital from Debt (\%)} = \frac{(100\% - \text{Tax Rate \%})}{100\%} \times \text{Debt Interest Rate}$$

EXAMPLE

$$\text{Cost of Capital from Debt} = \frac{(100\% - 50\%)}{100\%} \times 5\% = 2.5\%$$

Cost of capital from preferred stock: On an after-tax basis this is the yield on issue price. For the given firm it is 7%.

Cost of capital from common stock: Money raised by a new common stock issue should earn in the same proportion as the old equity.

Therefore, the after-tax cost of common stock capital is:

$$\text{Cost of Capital from Common Stock (\%)} = \frac{\text{Earning per share}}{\text{Price per share}} \times 100\%$$

EXAMPLE

$$\text{Cost of Capital from Common Stock} = \frac{\$2}{\$20} \times 100\% = 10\%$$

Cost of capital from surplus: If accurate information about stockholders' tax situations is not available, 75 per cent of the cost of capital from common stock is often used as the cost of capital from retained earnings, on an after-tax basis.

$$\text{Cost of Capital from Surplus (\%)} = 0.75 \times \text{Cost of Capital from Common Stock}$$

EXAMPLE

$$\text{Cost of Capital from Surplus} = 0.75 \times 10\% = 7.5\%$$

Weighted cost of capital: Over-all weighted cost of capital is the weighted average of costs of capital from each source.

Capital Source	(a) Portion of Capital (%)	(b) After Tax Cost of Capital (%)	(c) Weighted Cost Factor (c=axb)
Debt	30	2.5	75
Preferred Stock	10	7.0	70
Common Stock	30	10.0	300
Surplus	30	7.5	225
Total	100		670

$$\text{Weighted Cost of Capital (\%)} = \frac{\text{Total of Weighted Cost Factors}}{\text{Total Portion of Capital}}$$

EXAMPLE

$$\text{Weighted Cost of Capital} = \frac{670}{100} = 6.7\%$$

Fig. 1—Basic factor in evaluating the proposals requiring company investments is the cost of capital for the company. The example shown illustrates the calculation of cost of capital under given conditions.

able, since a firm may have more project opportunities than it can realistically undertake.

▶ Cost of Capital

There are reasons why the cost of one particular financing method is not necessarily the final cost figure that should be used in evaluation of a specific project. First, it is often difficult to assign particular funds to a specific project. More likely, the project is one of an approved list, and one or several methods of financing will be used for the entire list. Furthermore, it is desirable that projects throughout the years be evaluated on a common basis. For example, let us assume that debt financing is used in one period and that projects are evaluated and accepted on the cost of the debt. If in the next period higher-cost equity financing is utilized and projects are evaluated and accepted on the cost of the equity issue, it is obvious that a project might be accepted in the first period that would be turned down in the second period. Such practice could lead to the acceptance of poor projects in one case and to the turning down of good projects in another.

Since a company normally makes use of all available methods of financing open to it, and since it usually strives to maintain some balanced capital structure over the long run, a weighted figure approximates the average cost of funds to this particular company. This figure varies from company to company and is called the cost of capital. This cost of capital is sometimes expressed as a weighted average of the firm's costs for capital from different sources. These include the cost of interest on debt, the cost of dividend payments on preferred stock, the cost of maintaining present earnings per share on a new stock issue, and an opportunity cost for retained earnings and depreciation flows.

The costs for capital from debt and preferred stock are fixed by their originating agreements. Money raised by new issues of common stock must earn in the same proportion as the old equity, so that new shares sold in a common stock issue will not dilute present stockholders' earnings per share. Thus, every new share issued must earn the same amount the old share earned.

Capital from internally generated funds also must be considered as having a cost. Since retained earnings (surplus) could be paid out to stockholders for investment in comparable alternative opportunities,

earnings reinvested in the company should not be considered cost-free. Stockholders must pay tax on their dividends, however, and this tax is avoided if the earnings are retained.

Where there is no income tax, the cost of retained earnings and the cost of common stock are identical, since as stockholder equity, both sources of funds are interchangeable. If accurate information about stockholders' tax situations is not available, 75 per cent of the cost of capital from common stock is often used as the cost of capital from retained earnings. This provides for a 25 per cent capital gains tax, should earnings be withdrawn by the sale of appreciated stock, and also provides for an average stockholder's income tax rate of 25 per cent. Thus, stockholders in all tax brackets are recognized.

Funds retained through the use of depreciation charges offer one more source of funds to a firm. Although it may appear that such funds are cost-free to the firm, such is not the case. Since the firm's over-all costs can be reduced by the alternative uses for depreciation funds, a real opportunity cost is associated with the use of these funds.

First of all, there is a chance for depreciation funds to reduce the amounts that are used from other financing sources, such as debt, preferred-stock issues, common-stock issues, and retained earnings. Thus, the cost of the reduced portion would be saved, and these costs would equal the firm's cost of capital in the long run. Secondly, lacking a large investment program, the firm can always use funds retained through depreciation charges to reduce its capital structure. Over the long term, any such reduction in capitalization, given full disclosure, would be proportional to the firm's ideal capital structure, and the costs saved on the reduced portion

(a) Simple Payback

$$\text{Payback Period (Years)} = \frac{\text{Net Investment}}{\text{Incremental Income Per Year}}$$

EXAMPLE

$$\text{Payback Period} = \frac{\$1800}{\$300} = 6 \text{ Years}$$

(b) Simple Return on Investment

$$\text{Return on Investment (\%)} = \frac{\text{Incremental Income Per Year} - (\text{Total Depreciation} \div \text{Years to Depreciate})}{\text{Net Investment} \div 2}$$

EXAMPLE

$$\text{Return on Investment (\%)} = \frac{\$300 - (\$1800 \div 10)}{\$1800 \div 2} = \frac{120}{900} = 13.3\%$$

(c) Time-adjusted Rate of Return

$$\text{Present Value Factor} = \frac{\text{Net Investment}}{\text{Incremental Income Per Year}}$$

In a compound interest table find the interest rate corresponding to this present value factor and the number of years that the incremental income is expected (the economic life of the equipment).

EXAMPLE

$$\text{Present Value Factor} = \frac{\$1800}{\$300} = 6.0$$

On the 10 year row of the present value factors of a compound interest table*, we find the figure closest to 6.0 is that figure in the 12% column (5.983). This figure means that the present value of a stream of annual $1 payment for 10 years discounted at 12% is nearly $6 (actually $5.98). Thus, the present value of $300 per year for 10 years at about 12% is 300 times $6 which is $1800. Since the present value of the investment is $1800, the discount rate equating the present value of the receipts to the present value of the investment is 12%. Therefore, the time-adjusted rate of return for this project is 12%.

*See reference at end of article.

Fig. 2—Three techniques widely used to indicate project returns are *(a)* simple payback, *(b)* simple return on investment, and *(c)* time-adjusted rate of return. To illustrate these techniques, sample calculations are shown for each based on the conditions for one specific project. The project covers a new machine requiring a net investment of $1800 and promising a net incremental income (or savings) of $300 annually. The economic life of the machine is estimated at 10 years, after which there will be no further income and no salvage value.

PROBLEM

Determine time-adjusted rate of return for a project having non-uniform annual returns.

CONDITIONS

Project requires an immediate investment of $1000. Returns of $300 per year are expected for years 3 through 7, and returns of $200 per year for years 8 through 10. After year 10 no further returns are expected, and no salvage value is expected.

SOLUTION

Trial and error method is used to find a rate of return for which the present value of the returns is equal to the present value of the investment.

Since the project requires an immediate investment of $1000 and no other investment, the present value of the investment is $1000.

Try 15% as the rate of return required to make present value of the expected returns equal to the present value of the investment. From the 15% column of present value factors in a compound interest table* we find that the factor for 2 years is 1.745, for 7 years 4.465, and for 10 years 5.386. The mathematics of the tables indicates that to find the present value factor for a stream of equal annual receipts from year 3 through 7 inclusive, the factor for year 2 should be subtracted from the factor for year 7. This is because the factors listed in the tables are computed as of the end of the year. Similarly, by subtracting the factor for year 7 from the factor for year 10, we can calculate the present value of the receipts that start at year 8 and continue through year 10.

Time Period	Returns Per Year	Present Value Factor	Present Value
Years 3-7	$300	4.465-1.745=2.720	$816
Years 8-10	$200	5.386-4.465=0.921	184
			$1,000

Since the total present value of the returns discounted at 15% is $1000 and the present value of the investment is $1000, the time-adjusted rate of return of the project is 15%.

*See reference at end of article.

Fig. 3—Time-adjusted rate of return can also be computed for a project promising annual returns that are not uniform. A trial and error method is illustrated to determine rate of return under such conditions.

would approximate the firm's cost of capital.

It is apparent, then, that the reinvestment of funds retained through depreciation charges should require the same rate of return as the investment of outside funds. This means that the cost of using depreciation funds is identical to the firm's weighted cost of capital and can thus be ignored in calculations of the weighted cost of capital.

In the firm described in *Fig.* 1 with an after-tax weighted cost of capital of 6.7 per cent and taxed at a 50 per cent rate, the before-tax cost of capital would be 2 times 6.7 per cent, which is 13.4 per cent. This is because the firm must earn $4 per share before taxes to realize earnings per common share of $2 (we will ignore preferred dividends). The other 50 per cent of this $4 must be paid to the government.

It must be emphasized that if the rate of return is calculated after taxes, the cost of capital to which it is compared must be computed after taxes as well. Since tax considerations are frequently of considerable magnitude, particularly where heavy depreciation or write-offs are concerned, the rate of return of a project and the cost of capital should generally be compared on an after-tax basis.

The weighted cost of capital, with the cost of common stock being determined by the reciprocal of the price-earnings ratio, is not applicable to all companies. The compound growth rate of earnings per common share, a strong determinant of the price-earnings ratio, must be considered. In particular, a so-called growth company may have experienced a high compound growth rate of earnings per common share and thus command a fairly high price-earnings ratio in the market.

If the reciprocal of its price-earnings ratio is used as the growth company's cost of equity capital, the resultant weighted-cost-of-capital figure will be deceivingly low. If the growth firm accepts projects down to this weighted cost of capital, an interesting but unfortunate chain of events occurs. The firm would continue to recoup its cost of capital for a while, and earnings per common share would continue to grow. However, this growth of earnings per share would progress at a decreasing rate. Any decrease in the compound growth rate of earnings per share is normally accompanied by a downward re-evaluation of the firm's price-earnings ratio by the market. Such a downward re-evaluation results in an increased cost of capital.

In short, the weighted-cost-of-capital approach gives a static picture of a situation involving such dynamic factors as corporate debt policy, dividend policy, rate of corporate growth, and those elements involving the raising of equity capital. The weighted cost of capital is thus only an approximation at best. However, if its limitations are understood, the weighted figure can be quite useful.

▶ Evaluating Project Returns

During appraisals of an investment opportunity, four major financial characteristics must be considered: The net cash outlay required by the investment, including any necessary increase in working capital; the net incremental income that the project will return; the timing of the cash flows, both as investments and as returns; and the expected economic life of the project. The initial investment required by a project can often be exactly determined and can generally be more accurately estimated

PROBLEM

Compare two projects on the basis of their respective profitability indexes.

CONDITIONS

The company considering the two projects has a cost of capital of 15 per cent. Project A requires a net investment of $1000 per year for three years and promises returns of $900 per year for years 4 through 8 and returns of $300 per year for years 9 through 10. Project B requires a net investment of $1500 per year for two years and promises returns of $900 per year for years 3 through 7 and returns of $500 per year for years 8 through 10. No further returns are expected after year 10, and no salvage value is expected of either project.

Fig. 4—Comparison of projects by means of their profitability indexes is based on present values of investments and returns involved. Such comparison takes into account the time value of investment and return flows in the same manner as time-adjusted rate of return calculations. The examples used involve investments and returns spread over several years.

SOLUTION

Since the investments and the returns of both projects occur over a period of time, both investments and returns for each of the projects must be translated into present values in the same manner used to compute present value of returns in *Fig.* 3.

Time Period	Investments and Returns ($/Yr.)	Present Value Factor	Present Value of Investments	Present Value of Returns
PROJECT A				
Years 0–3	1000	2.450	$2450	——
Years 4–8	900	4.816 − 2.450 = 2.366	——	$2129
Years 9–10	300	5.386 − 4.816 = 0.570	——	171
	Totals PROJECT A		$2450	$2300
PROJECT B				
Years 0–2	1500	1.745	$2618	——
Years 3–7	900	4.465 − 1.745 = 2.720	——	$2448
Years 8–10	500	5.386 − 4.465 = 0.921	——	461
	Totals PROJECT B		$2618	$2909

$$\text{Profitability Index} = \frac{\text{Present Value of Returns}}{\text{Present Value of Investments}}$$

For PROJECT A: $\text{Profitability Index} = \frac{\$2300}{\$2450} = 0.939$

For PROJECT B: $\text{Profitability Index} = \frac{\$2909}{\$2618} = 1.111$

Not only is Project B more profitable than Project A, it is the only one of the two projects that promises to recoup its investment and the cost of capital on that investment.

than the possible income from the project, even in the case of less definite projects, such as research. The net incremental income resulting from a project often must be estimated. As such, the estimate is subject to some inherent risk of error.

Allocated costs of any kind have no place in the analysis of net income from a project. The only costs relevant to this analysis are those incremental costs actually incurred, just as the only relevant income is that received as a result of the project being undertaken. The economic life of a project is shorter than its physical life, its technological life, or the market life of its product.

Three techniques are normally used for evaluating the returns of a project relative to the required investment. These are payback, simple return on investment, and time-adjusted return on investment. Each has its advantages and disadvantages.

▶ Payback

There are several methods of calculating a payback. Perhaps the most popular method is to divide the net investment by the annual incremental income, as indicated in *Fig.* 2*a*. Other methods of payback might include provisions for tax considerations and depreciation allowances. The simple payback method offers the advantage of a simple, easily applied yardstick. Obviously unattractive projects can be quickly eliminated by this method.

However, since payback measures only the time within which the net investment will be recouped, it tends to overweigh the importance of liquidity in project comparisons; furthermore, the returns of many projects are not constant through the years. Payback is a useful measure when liquidity or technological obsolescence is of prime importance, but

it does not consider the economic life of the project or the returns after the investment has been paid back; and it provides no real basis for comparison with other alternatives or a figure that may be compared with the cost of capital.

▶ Simple Return on Investment

There are several methods of computing a simple return on investment. All are similar in that the incremental income produced by the project—often adjusted for taxes and/or an allowance for depreciation—is divided by the original net investment or the average book value. Any of these return-on-investment calculations has the advantage of being simple and easily applied, and several of these methods approximate the true return for some investments, but not one correctly takes into consideration the time value of money.

The simple return on investment assumes that the return in one year is just as valuable as the same return in another year. The fact is, however, that a dollar today can be invested at some compound earnings rate and is thus more valuable than a dollar at some point in the future. In short, the simple-return-on-investment method does not discount the future returns from a project to their present value so as to make the returns directly comparable with the investment, which generally is already in present-value terms.

Note that the simple return on investment figure obtained in *Fig. 2b* represents the ratio of the incremental income to the average investment after we provide for the amortization of the investment over its economic life. Since the depreciation gradually reduces the investment to zero at the end of the project's life, the average amount invested in the project is one-half the original investment.

▶ Time-Adjusted Rate of Return

Although its calculations are more complex, the time-adjusted rate of return (often called the discounted-cash-flow method) overcomes the disadvantages of the two techniques just mentioned. It is possible to discount the time shape of both the

PROBLEM

Calculate the profitability index for a project in which depreciation is a significant factor.

CONDITIONS

Assume an immediate net investment of $1800 for a new machine promising a net incremental income of $300 annually. Also assume that the depreciable life is 10 years, with no salvage value. Assume further that the firm's tax rate is 50 per cent, and its after-tax cost of capital is 5 per cent.

Fig. 5—Where significant depreciation is involved, calculations of return on investment and profitability index should be made on an after-tax basis. Calculations are shown for profitability index of the project examined in *Fig. 2*.

SOLUTION

The annual value of after-tax returns is equal to the net annual incremental income less the annual income tax on the increase in taxable annual income. The increase in taxable annual income is equal to the net annual incremental income before tax, less the annual depreciation allowance.

Increase in Taxable Annual Income = Net Incremental Annual Income − Annual Depreciation Allowance

EXAMPLE

$$\text{Increase in Taxable Annual Income} = \$300 - \frac{\$1800}{10} = \$120$$

Annual Tax on Increase in Income = Tax Rate × Increase in Taxable Annual Income

EXAMPLE

$$\text{Annual Tax on Increase in Income} = 0.50 \times \$120 = \$60$$

Annual After-Tax Return = Net Incremental Annual Income − Annual Tax on Increase in Income

EXAMPLE

$$\text{Annual After-Tax Return} = \$300 - \$60 = \$240$$

Present value factor for annual returns at 5% over 10 years is found from a compound interest table* to be 7.913.

Present Value of After-Tax Returns = Annual After-Tax Return × Present Value Factor

EXAMPLE

$$\text{Present Value of After-Tax Returns} = \$240 \times 7.913 = \$1899$$

$$\text{Profitability Index} = \frac{\text{Present Value of After-Tax Returns}}{\text{Present Value of Investment}}$$

EXAMPLE

$$\text{Profitability Index} = \frac{\$1899}{\$1800} = 1.055$$

*See reference at end of article.

return flows and the investment flows to common dollars such that their comparison is truly valid. Not only does the time-adjusted rate of return make this return-to-investment comparison decidedly valid, but the discounting technique provides the basis for a meaningful comparison between the rates of return of alternative investments. Using this technique as a basis, it is possible to rank two alternate projects even though the amounts and timing of their investments are different.

A set of present-value or annuity tables is used for the various computations that are necessary in a time-adjusted rate of return calculation. An example of such a calculation for time-adjusted rate of return is shown in *Fig.* 2c. The set of tables enables the incremental income and investments of a project over the years to be discounted back to present value. One can obtain the time-adjusted rate of return for a project by determining the discount rate which equates the present value of the stream of receipts to the present value of the stream of investments.

Present-value tables are available from various sources, and many are based on slightly different assumptions. All such tables assume that the income received from a project is reinvested. Some tables assume that the annual returns from a project will be received (and reinvested) in equal monthly payments, while other tables are integrated and assume that the annual project returns are continuously received and continuously reinvested. The difference in such assumptions is slight, and it rarely affects the outcome of a comparison.

The present value table is used to convert the payback period into the time-adjusted rate of return for an investment with a given economic life. It should be noted that depreciation over the economic life of the investment is automatically allowed for, since the discount rate equating the present values of the returns and investment is the rate of return after an annual provision for amortizing the original investment.

A nonuniform stream of returns from an investment presents one complication. It is also possible that the investment itself may be made in several installments, particularly in the case of a research project. However, if it is remembered that we obtain the time-adjusted rate of return for a project by determining the discount rate which equates the present value of the stream of receipts to the present value of the stream of investments, the complication is easily solved. This rate must be found by trial and error. An example of such a problem is shown in *Fig.* 3.

Although this or some more sophisticated variation of the time-adjusted rate of return may provide the most useful return figure presently available, this method is not a panacea for all investment problems. It must be pointed out that there are some assumptions inherent in the method which make its validity questionable.

First, the time-adjusted rate of return method produces a single figure that is supposedly the project's rate of return throughout the entire life of the project. It is reasonable to think of a project as having more than one rate of return at different points in its life. Second, and most important, the use of the time-adjusted rate of return method assumes that the returns from the project will be reinvested at exactly the same investment rate that the particular project is bringing. That this situation would actually occur with any regularity is highly improbable. Third, the time-adjusted rate of return itself provides no way to rank many alternatives in order of desirability; for instance, would you rather have a 20 per cent project for five years or a 15 per cent project for 10 years?

Profitability Index

One procedure that ranks alternative projects in the order of their desirability also provides information about the cost of capital recovery. If the stream of returns from a project is discounted to present value at the firm's cost of capital, a dollar figure is obtained which represents the worth of the project to the firm today should the returns be reinvested at the cost-of-capital rate. Since the cost of capital is the minimum investment standard, it is reasonable to assume that money can be utilized by the company at that rate. If the stream of investments required for the project is likewise discounted to present value at the cost of capital, a dollar figure is obtained which represents the cost of that project to the firm today. A ratio of the present value of the stream of returns and the present value of the stream of investments, both discounted at the

THE AUTHORS

THOMAS C. STOUT has been active at Arthur D. Little Inc. in systems engineering work involving production systems, plant design, research-and-development evaluations, machine design, and product development. Previously he worked on mechanical design problems in the Research Div., United Shoe Machinery Corp., and was responsible for design and operation of a testing facility for nuclear-reactor components as chief test engineer in their Atomic Power Dept. He also worked as an administrative assistant in the controllers department of a retail chain in Zurich, Switzerland, where he was involved in the planning and operation of a data-processing system. Mr. Stout has a B.E. degree in Mechanical Engineering from Yale University and an M.B.A. from the Harvard Graduate School of Business Administration.

firm's cost of capital, is very useful. It may be called the profitability index.

If the profitability index for a given investment opportunity is equal to or greater than one, the project promises returns that will recoup both the investment and the cost of capital of the investment. The larger a project's profitability index above one, the greater are the expected returns over and above the minimum standard, and the more attractive the project is. Thus, comparing the financial attractiveness of two alternative projects, we find that the project with the higher profitability index is the more desirable, *Fig.* 4.

The present value of any salvage value recovered at the end of the project's useful life should be subtracted from the investment. Any decrease in working capital necessitated by the project would fall in this category. In this case, the present value of the related funds at the end of the project's life would be deducted from the original net investment in the calculations. If any sizable depreciation is involved, return calculations should be made after taxes; this is due to the tax shield offered by depreciation, *Fig.* 5.

Whether before-tax or after-tax returns are calculated, they must be comparable with the cost of capital. Thus, if before-tax returns are calculated, the cost of capital used as the standard must also be computed before tax. Generally speaking, projects involving depreciable assets should always be calculated after taxes. The after-tax cost of capital of a firm taxed at 50 per cent is approximately one half its before-tax cost of capital.

For individual investment opportunities, the profitability index is more significant than any rate-of-return calculation. Sight cannot be lost of rate of return, because over-all company profitability is often judged by this criterion. However, for the evaluation of investment opportunities within the broad capital budgeting framework of the company, the profitability index provides better information with which to work. Furthermore, accepting for investment those projects with the highest profitability indexes maximizes the present value of the returns of opportunities accepted.

The prospective profitability of an investment is but one of the several criteria upon which the desirability of the proposed project is judged. Thus, a proposal for an employee's cafeteria may be quite favorably considered in spite of its apparent lack of financial returns. Nonetheless, profitability is a consistently important basis for decisionmaking, and the index presented effectively measures the magnitude of this profitability.

▶ Risk Considerations

There are two problem areas inherent in the rate-of-return/cost-of-capital considerations. The first is the level of risk associated with the company itself; the second is the uncertainty about the accuracy of the estimates used in the return calculations.

A firm's cost of capital is inherently dependent on the prices its securities will command in the marketplace. Thus, the debt interest rate, the preferred stock yield rate, and the common-stock price-earnings ratio all reflect the market's appraisal of the general level of risk in the company. Any project with a different level of risk than that level for which the cost of capital has been computed will affect the numerical value of the cost of capital in the long run.

Thus, some firms find it appropriate to adjust the minimum standard for a given project in accordance with the relative risk involved in the proposed project. The amount of the adjustment is an extremely difficult problem to approach quantitatively, and much managerial judgment must be used. Some firms have established such project categories as equipment replacement and new products and then assigned risk divisions within these categories. Minimum-rate-of-return standards are then set for the various categories and divisions, the entire structure being based on the firm's cost of capital.

When a minimum-rate-of-return standard other than the cost of capital is used in a profitability-index calculation, returns of that particular project should be discounted to present value at the minimum-return standard for that project's category. The investment, however, would be discounted at the firm's cost of capital as explained. This procedure has the effect of lowering the profitability index for a project in accordance with its risk level. If the assumptions and limitations inherent in the cost-of-capital computation are understood, much success can be derived from a risk-categorization system.

It is quite possible to approach the problem of uncertainty in the estimates of a project's returns by the use of probabilities. In the generally prevalent

JOHN W. WEBER is a member of the staff of McKinsey & Co. Inc., management consultants. When the accompanying article was written, he was engaged in systems engineering work at Arthur D. Little Inc. Prior to that he worked in the general area of production control with the consulting firm of Alden E. Stilson & Associates. On active duty as an officer in the Navy he was concerned with production, design, and inspection work related to ship repair and construction. Mr. Weber has a B.S. degree from Yale University and an M.B.A. from the Harvard Graduate School of Business Administration. He is also a registered professional engineer in the state of Ohio and a member of Sigma Xi.

method of using them to estimate a given year's returns from a project, probabilities are implicity assigned to various possible return rates; then one figure is chosen as an expected value. The practice of explicitly assigning probabilities to various levels of possible receipts from a project requires that the probabilities themselves be estimated. However, formalizing this process does categorize the thinking behind a project and makes the approach to the problem more rigorous. After probabilities are assigned, the resultant expected values are used for the returns. If the flow of investment funds is also uncertain, one can use probabilities to arrive at an expected value for the investment also.

It should be noted that when probabilities are used to calculate the expected value of a return or investment, the risks associated with the uncertainty of the estimates are automatically considered and included in the solution. Thus, a project whose return calculations are based on expected values should be compared directly with the cost of capital. In short, no adjustment of the minimum-return standards for different risk projects is necessary if probabilities are used in calculating the rates of return.

If probabilities in rate-of-return analysis are to be used successfully, it is necessary that the results of the projects be tabulated. In this manner, the accuracy of the estimating personnel can be regularly reviewed with a mind to improving the quality of the estimates. Such procedures can also be used to encourage more accurate, realistic estimates from personnel who tend to be overly optimistic or pessimistic. Most firms are several years away from using probabilities in investment analysis. However, as the actual returns from the various projects are tabulated and compared with the estimated returns, and as the company's experience base with probability techniques broadens, the use of such analysis will produce better quantitative data for managerial decisions.

Better techniques for evaluating investment projects will result in better decisions within the firm, and these better decisions will lead to closer managerial control over the firm's investment climate. The commonly used techniques—such as share of market and historical return on assets—can often lead to poor decisions, but the comparison of a project's returns relative to the firm's cost of capital will provide effective quantitative data upon which decisions can be based.

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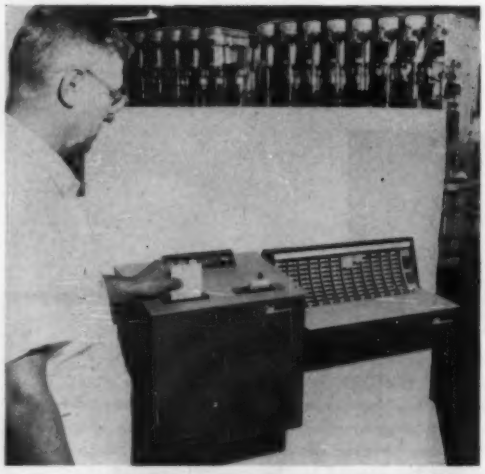
production data collection system

EMPLOYEE BADGE, punched job card, and manual "keyless" keyboard are all being used to feed information into a production data system. International Business Machines Corp. has developed the system to permit rapid transmission of information from in-plant locations to a manufacturing control center. The photograph shows one of several in-plant stations which transmit information to a central control office where the data are recorded in punched-card form.

Variable information such as number of parts produced can be entered in up to twelve columns. The keyboard has vertical slides instead of keys and a concave front which is designed to improve the user's view of the surface. The variable data are entered by moving the slides to positions corresponding to the values zero through nine or blank. Before dispatching the report, the operator can check the accuracy of his entry by reading the number which appears in a single row across the lower portion of the keyboard plane.

To identify himself, the employee takes off his badge and inserts it in a special reader. The laminated plastic badge is about two by three inches in size and contains typical information such as employee number, name, and perhaps his photograph in an ordinary manner. The badge is also punched to indicate the man's number and department. The reader senses these punchings to transmit information to the control center.

The basic facts concerning the job involved are recorded on a punched card given to the employee when the job is assigned. This card is inserted in another reader slot. The insertion of the job card triggers the



transmission of data from all three sources to the control center. The data are transmitted by cable from the input station to the card punch at the manufacturing control center.

When the transmission is completed, the card reader, badge reader, and manual keyboard auomatically reset to normal position. The badge automatically pops up from the badge reader, and the employee can put it back on his shirt or coat.

DIAL MACHINE ASSEMBLES TRANSISTOR CASES

TRANSISTORS are inherently small—a characteristic which makes them extremely difficult to handle with automatic machinery. To compound this problem, transistors are susceptible to contamination and usually must be handled in controlled atmospheres. To satisfy this requirement, air-tight hoods are installed over transistor manufacturing equipment, and operator access is usually limited.

These were some of the problems faced by Precision Welder and Flexopress Corp. in developing an automatic machine to assemble and weld transistors. The transistor in question consists of two parts, a base and a cap. Both are awkward to orient and handle. Each base is less than 3/16 inch in diameter by 1/8 inch in height and has three 3-inch long soft wire leads projecting from it. The cap is approximately 3/16 inch in diameter by 3/16 inch in height and has a 1 1/8-inch long evacuation tube projecting from it. Both parts are made of gold-plated steel and fit together tightly. After assembly, the parts are welded. The weld must be gas tight and must be made in a controlled atmosphere.

A six-station, dial-type assembly machine for accomplishing these operations is shown. For clarity, the atmosphere hood has been removed. Output of the machine is approximately 1850 transistor units per hour and represents a large increase over former production methods.

A unique moving chain feeder is used to transport transistor bases to the loading station of the assembly dial. The bases are first manually loaded in a wooden fixture which holds twenty units. The operator then moves the fixture against the moving chain so that every other base is aligned with a slotted holding bracket on the chain. When the fixture is withdrawn, ten bases remain in the chain. The remaining ten bases in the fixture are loaded in a similar manner.

The moving chain carries the bases to the loading position of the dial where a loading mechanism pivots against the chain and a solenoid operated plunger pushes a base into the mechanism. As the mechanism pivots back over the dial, the wire leads of each base are gathered together so that they will feed into a small hole in one of the six cartridge electrodes on the dial. The loading mechanism then lowers and releases the base into the empty dial electrode at the first station.

The transistor cap is fed onto the base at the third station of the dial. Caps are fed from a vibratory feeder and guided into a sloping track. Midway down the track, an escapement stops the caps and releases one cap at a time down a tube to a loading fixture. On the downward stroke of the fixture, the cap is positioned and firmly seated onto a base.

At the fourth station of the machine, a photoelectric sensing unit checks the assembly to see that the cap is correctly mounted on the base. If this is not the case, the unit stops the machine. The cap is welded to the base at the fifth station. A fixture lowers an upper electrode over the cap at the same time that a lower electrode is raised against the cartridge electrode set into the dial. The weld is made by a 10 kva C-frame welding unit. At the sixth station, the completed assembly is unloaded into a discharge chute by an automatic lift and kick ejector.

The assembly and welding machine is mounted on a 5 foot square table top which provides a leakproof base for a dry box hood. Drive units for the dial and the station tooling are mounted under the table top along with the welding transformer. A separate cabinet houses the controls for the welder and work performing mechanisms.

Transistor components are assembled and welded together in this six-station, dial-type assembly machine. Triangular moving chain feeder in the foreground is used to transport transistor bases to loading station of dial. Cap parts are fed from the vibratory bowl in the left background and inserted on the bases at the third station of the dial. The parts are welded at the fifth station.

Incoming steel plate

AUTOMATION TODAY

MAKING POWER CIRCUIT BREAKERS

By E. J. GAGLIARDI and W. W. WEBBER
Manager, Manufacturing Power Circuit Breaker Dept., Superintendent, Manufacturing Engineering Westinghouse Electric Corp., Trafford, Pa.

FOR MANY YEARS, job shop techniques have been the rule in the manufacture of circuit breakers used in high voltage transmission and distribution circuits. Recently, however, completion of a new plant designed specifically for circuit breaker manufacture has enabled Westinghouse Electric Corp. to adopt in-line production and assembly methods for these electrical components.

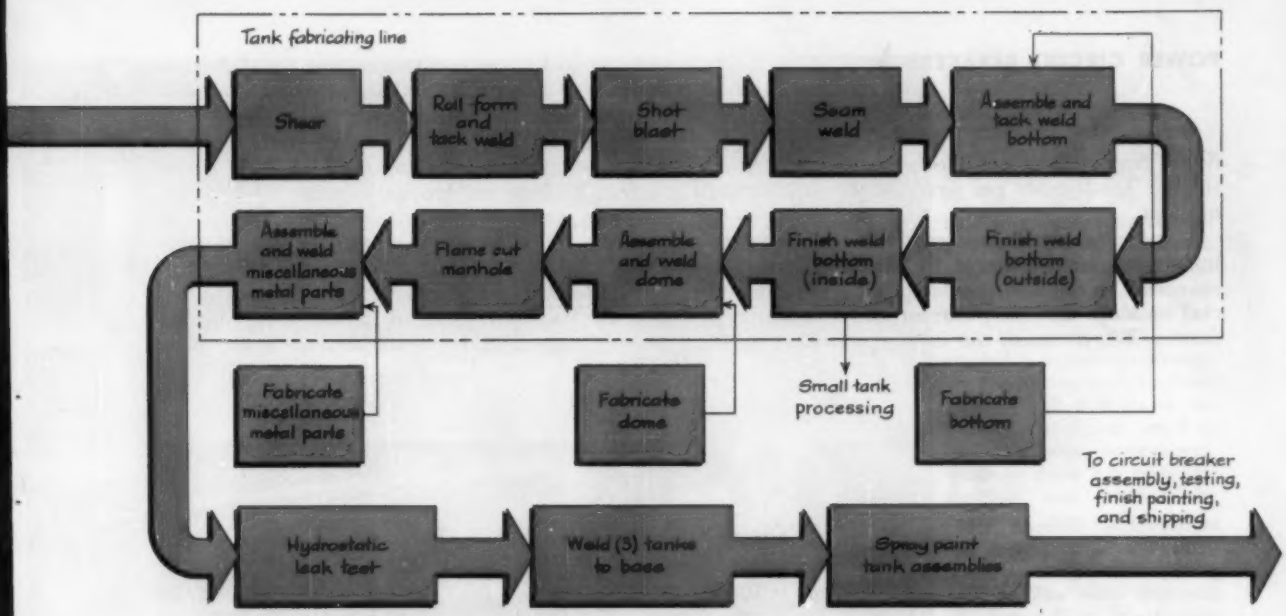
A need for additional manufacturing facilities was first evidenced by the results of a 10-year market forecast made in 1956. According to the forecast, apparatus requirements of the electric utility industry would eventually overtax existing company facilities for the production of its share of the market for circuit breakers. Accordingly, authorization was given which resulted in construction of a new plant in Trafford, Pa. This plant replaces the former circuit breaker manufacturing facility at East Pittsburgh, Pa.

Under the general direction of a superintendent of facilities planning—a specially appointed senior member of the Manufacturing Dept.—detailed planning began when 30 committees were established and charged with responsibility for planning specific areas of the new plant. Each committee had as its chairman a foreman of an operating department at the old plant. Committee membership included staff supervisors, manufacturing engineers, and industrial engineers. Under the setup, each committee was responsible for detailed planning of the area for which its foreman-chairman would be responsible in the new plant. Direct responsibility for integrating and co-ordinating individual plans was borne by the superintendent of facilities planning.

The general philosophy under which the committees were instructed to function called for them to eliminate as many as possible of the production problems that had existed previously. In addition, the committees were to make the fullest practical use of modern production techniques so as to go beyond mere problem-solving.

At the same time that planning for operational areas was under way, the departmental production control system was revised to convert to a punched card basis. Now, the system provides weekly access to all manufacturing and inventory control information and to machine load data and production followup sheets. In addition, the production cost system has since been put on punched cards. In another planning step, computer-prepared studies led to the decision to produce components in economic order quantities.

The products around which planning centered and which are in production at the new location



1 **Sequence diagram illustrates steps in production of tank assemblies for circuit breakers. At start of fabricating line, tank shells for all sizes of circuit breakers are processed together. After bottoms are welded to shells, assemblies for small and medium-voltage breakers are transferred to a branch conveyor for further processing. Large tank shells for high-voltage circuit breakers proceed on main fabricating line and then to leak testing, welding, and spray painting areas before being assembled into complete circuit breakers.**

are primarily oil filled circuit breakers of the floor and frame-mounted types. In each type, three separate tanks are used to enclose the circuit interrupting devices required for three-phase electrical circuits. Frame-mounted breakers are classed as medium voltage equipment (14,400 to 69,000 volts) and floor-mounted breakers are used for high voltage applications above 69,000 volts.

A third type of breaker is produced in which all three poles are contained in a single tank. This unit is used principally for low-voltage applications on distribution circuits at 14,400 or 23,000 volts. Since it is made in limited quantities on a customer order basis, substantial investments in production equipment were not warranted for this product.

Although oil filled circuit breakers account for the largest volume of production, in planning the new plant it was essential to provide for increased

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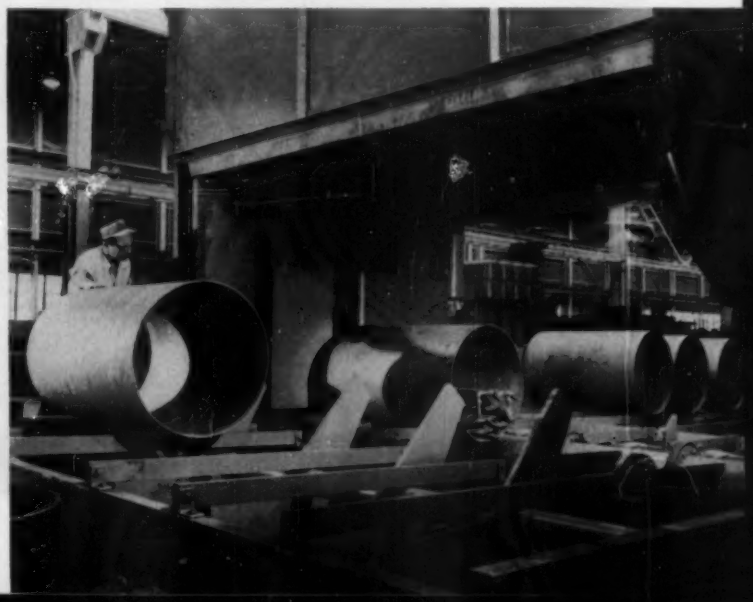
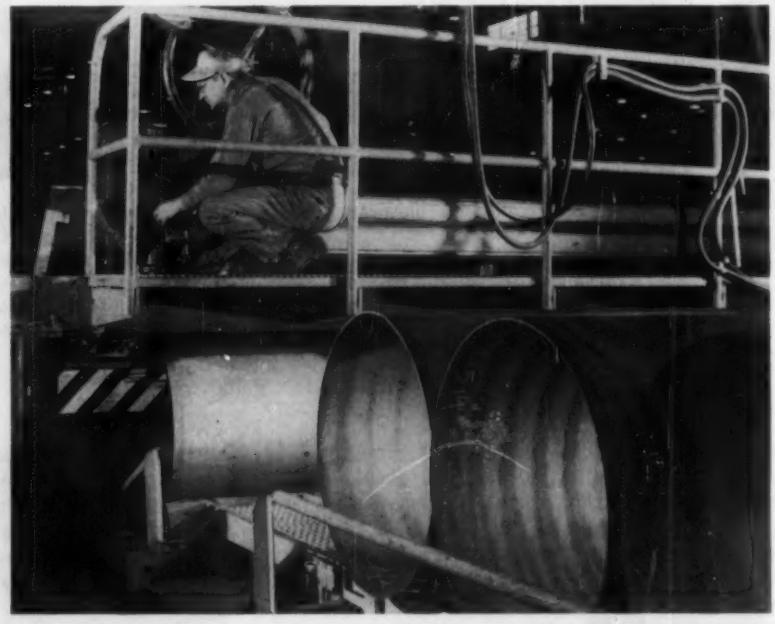


Roll formed and tack welded tank shells are shot blasted at this automatically cycled station in tank fabricating line. Shells with diameters from 24 to 66 inches and lengths up to 110 inches can be accommodated. When doors have been lowered on either side of a tank shell in work position, center, the shell is rotated on powered rolls. Shot is then directed from nozzles on reciprocating boom to blast-clean both internal and external walls of shell. After shot blasting cycle, boom is reciprocated a second time so that shot and residue material can be removed by air blast. At the end of the cleaning cycle, the doors open automatically and the finished shell is ejected to an accumulating line leading to next station. Incoming shell, left, is then moved automatically into work position.

future production of gas filled types. In these types, sulphur hexafluoride gas serves as the interrupting medium.

In a typical circuit breaker, the circuit interrupting devices are submerged in oil. Each breaker is connected to the line it protects by two porcelain-clad bushings that carry current to the interrupting devices. When closed, the breaker contacts remain engaged so long as excessive current is not detected by current transformers which surround the bushings. If excessive current is detected, relays trip latches that hold the spring-loaded contacts closed. The breaker contacts then open in 0.05 second or less. To close the breaker contacts, air is admitted from a self-contained pressure tank and acts on a piston. The piston, working through linkages, closes the contacts.

Tanks, assembled bushings, operating mechanisms, and all machined parts are produced in the new plant. Components not manufactured in the plant



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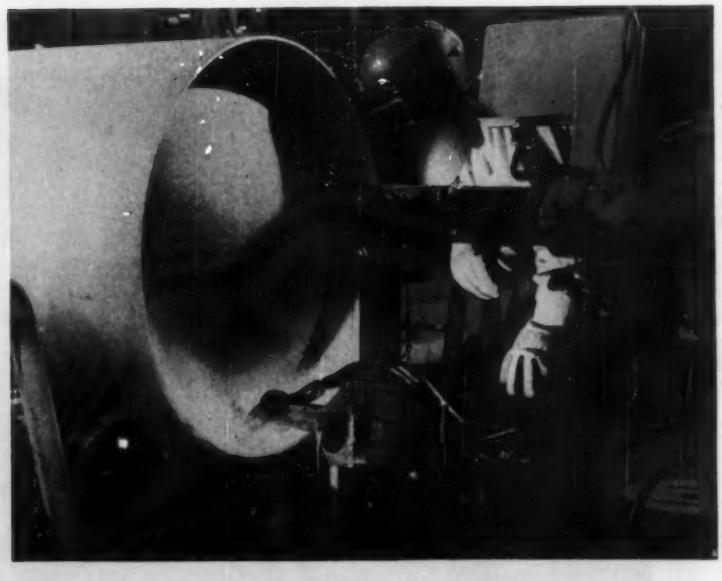
Mechanically cleaned tank shells are next moved by gravity conveyor to a semi-automatic seam welding station. Here, each shell is placed on cradle rolls which are rotated to position the tack welded seam under a welding head. A copper backup bar is then pressed against the inner surface of the longitudinal joint by an air-inflated tube, and welding head travel is initiated. Welding is by submerged arc process at a speed of approximately 24 ipm for ¼-inch thick material. After welding, shells are moved by gravity conveyor to a station where tank bottoms are assembled and tack welded in place.



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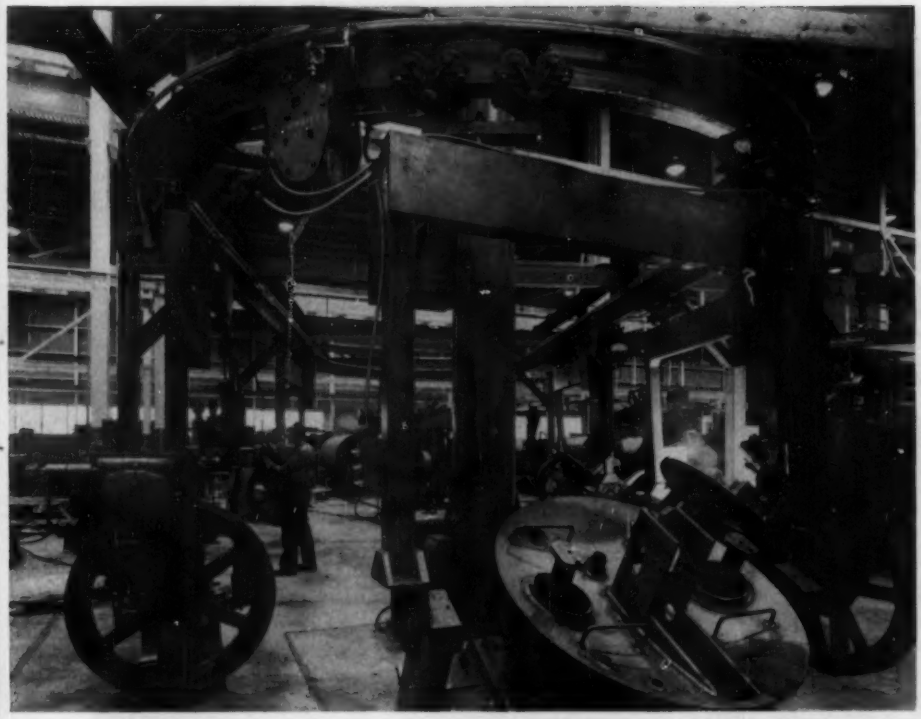
Bottoms are finish-welded to tank shells with external and internal seams applied at two separate stations in tank fabricating line. Shown are facilities for applying external seam welds. In welding, operator advances welding head on boom until welding wire contacts work. He then presses a pushbutton to supply welding current and to start the assembly rotating on cradle rolls. During the process an automatic seam follower keeps the welding head in position. After a seam is completed, operator presses a pushbutton to retract the head and eject the tank shell to a discharge conveyor. At this point, flow of workpieces along the tank fabricating line divides. Smaller tanks are transferred to a branch conveyor where a number of metal fittings are welded on. Larger (55 to 66-inch diameter) tanks for high-voltage circuit breakers continue on the main fabricating line.



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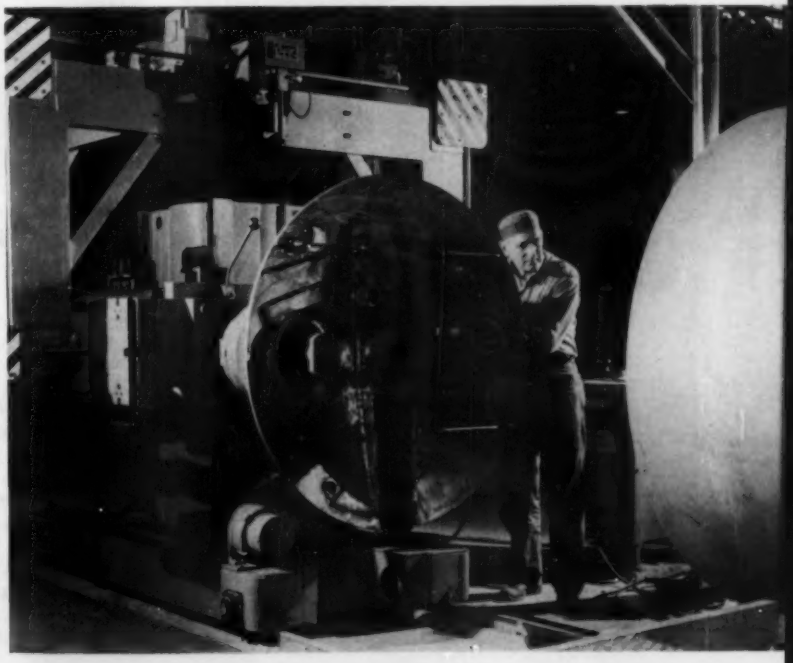
In an area just off the main tank fabricating line, domes for large tanks are assembled and welded on a five-station carousel. Carriers, suspended from a monorail, have independent drive systems so that each carrier can be positioned where needed. Assembly fixtures on the carriers can be tilted through 359 degrees to facilitate downhand welding of all dome components. When a dome has been assembled and welded, its carrier is moved to a position adjacent to a work station on the main tank fabricating line (background in photo). There, the fixture containing the welded dome is removed from the carrier and bolted to a rail truck that interconnects the carousel and the tank fabricating line.

include porcelain insulators, air compressors, and high pressure air storage tanks.

The manufacturing sequence begins with delivery of bulk steel from a storage yard to three parallel fabricating lines. Each line is devoted to the production of a specific major structural part of a circuit breaker. On one line, structural frames and cabinets for operating mechanisms are fabricated.



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When a fixture containing a welded dome has been transferred to this truck, an operator first adjusts the height of the dome to correspond with that of a high-voltage tank shell on the main fabricating line. He then moves the truck forward on its rails and halts it until motor-driven clamps on the truck squeeze the tank shell into a true circular shape. When the shell is properly rounded, the truck advances the dome into position for welding. Upon completion of the weld, the fixture is returned to the carousel where it is remounted on its carrier for assembly of another dome.

7

Large tanks move from the dome-welding station to a workstation where a circular manhole is burned into the tank wall with an oxyacetylene cutting torch. Movement of the torch is controlled by two templates, one of which is the steel ring that will next be welded around the circular opening. Use of this ring as a template for controlling the radius of cut avoids discrepancies of fit caused by individual variations among parts. The second template is contoured to the radius of the tank wall, and controls in-and-out motion of the cutting torch so that the flame is always at the proper distance from the tank wall. After cutting, the tank is moved to a final station in the fabricating line where the ring and other metal parts are welded to the tank. Following these operations, the tank is moved by crane to a hydrostatic test stand where it is checked for leaks. Then, large tanks are welded in groups of three to pairs of steel foundation beams.

Another line is used for fabricating breaker tanks, while domes are produced on the third fabricating line.

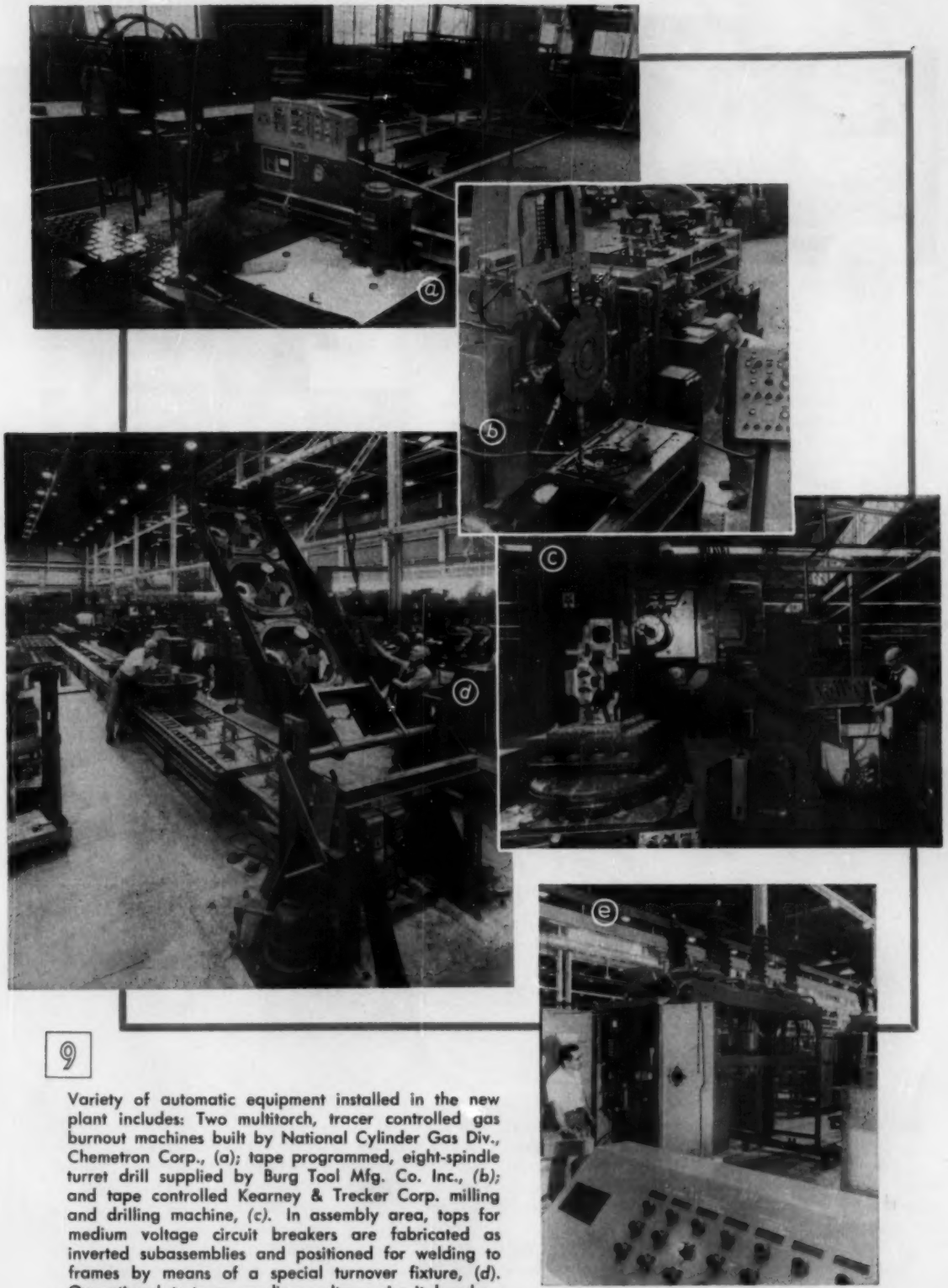
After the structural members have been processed into subassemblies, they arrive at a cross-plant railway and are transferred to a three-aisle circuit breaker assembly area. Other components and subassemblies, produced in a separate manufacturing building, are likewise routed to the assembly area.

Each aisle in the assembly area is used to produce a different circuit breaker type. Two of the aisles—for medium and high voltage breakers—include multistation, conveyorized assembly lines with personnel at each station responsible only for particular phases of a total assembly operation. The third aisle has been set up to produce low voltage circuit breakers by more or less conventional methods. In general, operations in all three aisles follow the sequence of assemble, test, paint, and ship.

Manufacturing innovations in the new plant include use of multistation, progressive fabrication and assembly lines; numerically controlled machine tools; tracer-controlled welding equipment; and an extensive system of materials handling equipment. The processes were developed so that product quality is more a function of machine effectiveness than individual skills. Some of the practices and equipment employed in the new plant are illustrated in the accompanying photographs.

8

After the tanks have been welded to foundation beams, the assemblies are moved by overhead crane to this spray booth where they are painted. Hoist shown is used to facilitate painting of upper portions of tank assemblies. Pushbutton controls enable operator to move the hoist as high as 18 feet above the floor and to any point around an assembly. Paint solids are collected at one end of a water trough below floor gratings. Solids are trapped by a series of weirs and screens ahead of pumps that circulate the water continuously through the trough.



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Variety of automatic equipment installed in the new plant includes: Two multitorch, tracer controlled gas burnout machines built by National Cylinder Gas Div., Chemetron Corp., (a); tape programmed, eight-spindle turret drill supplied by Burg Tool Mfg. Co. Inc., (b); and tape controlled Kearney & Trecker Corp. milling and drilling machine, (c). In assembly area, tops for medium voltage circuit breakers are fabricated as inverted subassemblies and positioned for welding to frames by means of a special turnover fixture, (d). Operational tests on medium voltage circuit breakers are made in phases at stations along two parallel test lines, (e). At each station, test trays may be swung into position so that operators can control tests without moving to central console.

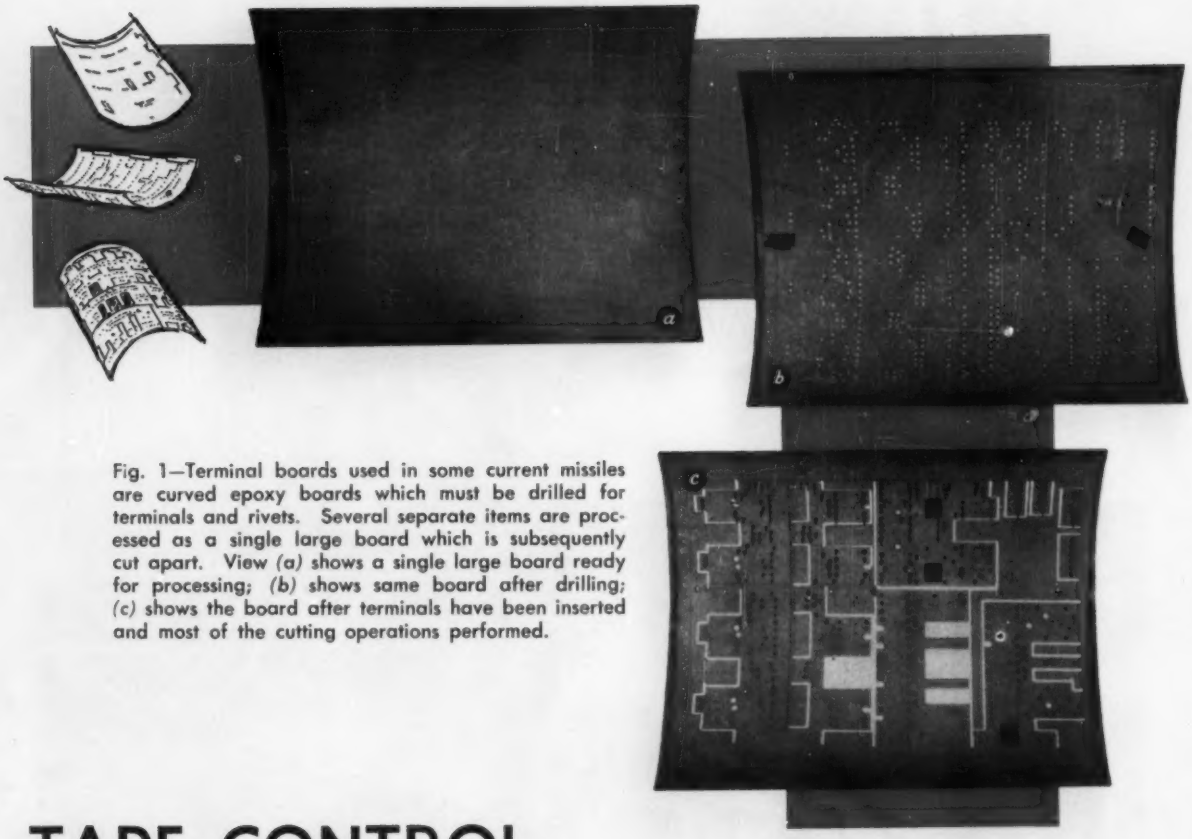


Fig. 1—Terminal boards used in some current missiles are curved epoxy boards which must be drilled for terminals and rivets. Several separate items are processed as a single large board which is subsequently cut apart. View *(a)* shows a single large board ready for processing; *(b)* shows same board after drilling; *(c)* shows the board after terminals have been inserted and most of the cutting operations performed.

TAPE CONTROL SPARKS PROCESS REVISION IN TERMINAL BOARD PRODUCTION

By **R. B. WOODWARD**, Chief Manufacturing Engineer, Assembly Dept., Missile Systems Div., Raytheon Co., Andover, Mass.

TERMINAL boards curved on approximately a 7-inch radius are among the important components produced by Raytheon Co. for some missiles. A typical epoxy board is a 120-degree segment of such a curve and has over 600 holes drilled and counterbored for terminals to be inserted. The board is eventually cut into 8 to 12 pieces of varying size and shape. Each piece has terminals and possibly cable brackets and tube shields riveted to it, and the board pieces are, in turn, riveted to a metal chassis.

Initial production was started with several manual operations. In view of the great number of circuit changes and the initial expense, a jig for drilling the board was not practical. Production was therefore set up by creating a reproducible drawing from engineering information and photographing hole locations on each board. With the aid of saddle type holding fixtures, an operator would manually and visually locate the board in a drill press and drill the holes as close as possible to the centers of the location bull's-eyes. Quality and quantity of production were obviously directly influenced by operator dexterity and fatigue.

For ease of manufacture, all possible operations are put into the board before cutting it apart. After

Curved terminal boards used in many missiles require a large number of drilling and cutting operations. Under previous manual methods, low production rates and lack of uniformity presented serious cost barriers. The author highlights some of the improvements obtained and related influences resulting from application of tape control in processing such terminal boards.

the curved board has been drilled, counterbored, and has terminals inserted and components installed, it is cut up into many segments. Under manual control most of the cutting operation was performed on a router with the aid of a template. The board was sent from the router to a band saw for narrow cuts. All the pieces of each board had to be kept together through succeeding assembly operations because they were not interchangeable with similar pieces.

After the board has been cut apart, its individual pieces are riveted into a metal chassis. Under manual operation it was necessary to match drill each segment in position in its chassis. Since the chassis requires a plating operation after drilling, it was necessary to package all the pieces of the board and identify the package with its particular chassis in order to perform the assembly operation after the chassis was returned from plating.

Process Changed

Using a tape-controlled drilling machine manufactured by Hillyer Corp., Raytheon accomplished a breakthrough in automatic machining operations. The basic machine included a tape control and provided point-to-point location of a single flat workpiece under a drill head. Conversion to rotary motion was required for the curved boards. Since all engineering information for the boards is dimensioned along the surface, it was necessary to adapt the equipment so that a turn of a shaft from the control box represented a given surface measurement.

The design developed makes ten turns of the shaft represent one inch of surface measurement on boards having any one of three different radii. In order to accommodate different radii without use of special gears, each work holder was designed with a built-in pulley of the same diameter as the dimensioned surface. Since maximum travel is 120 degrees, a steel tape can be screwed to the pulley to drive it. When work holders are changed, the steel tape is screwed to the pulley on the new holder and an idler adjusted for the difference in diameter. In this way, a given movement of the steel tape produces the same movement of a point on the surface of a curved board in any work holder.

With this arrangement day-long accuracy of plus or minus 0.001 inch could be obtained; one operator could run several machines; and most important at this stage was that engineering changes could be made simply by masking the old set of holes in the control tape and punching new ones. Also, since the system uses a Mylar tape four inches wide, it is feasible to record the Engineering Authorization

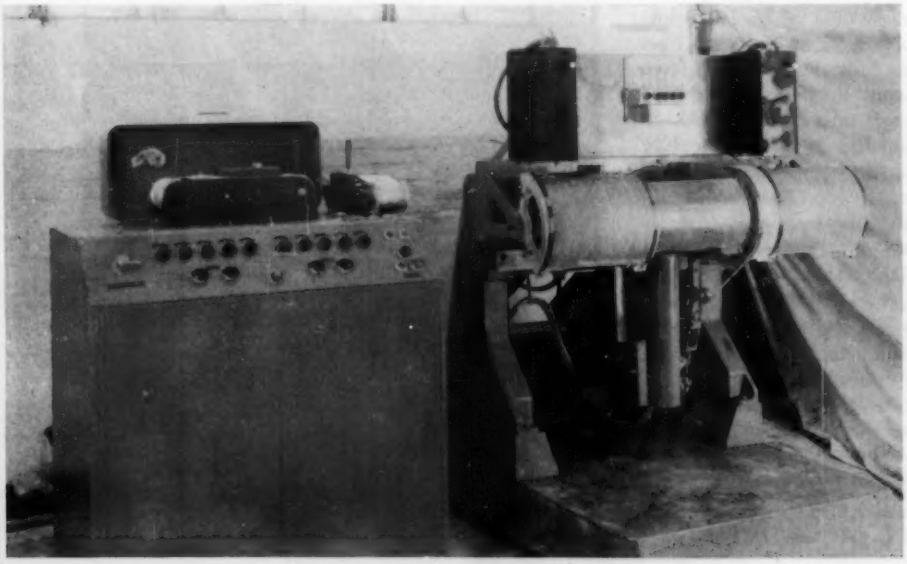


Fig. 2—Tape controlled drilling machine was adapted to automatically drill holes in two curved terminal boards simultaneously. Control tape used is a Mylar tape four inches wide. The unit to hand punch this tape is mounted on top of the control console and at the right of the tape reader. Design of the work holders and means for positioning them under the drill heads allows direct input of linear dimensions on the curved surface without computations involving radius of the board and angle of motion required.

Number on the margin of the tape opposite each change.

The tape is prepared from engineering dimensions by arbitrarily locating an origin and referencing all dimensions from it. It is most convenient to keep the work surface in the first quadrant so that all dimensions are plus. The tape is punched by hand in a unit providing a holder for two rolls with a numbered grid between the two. The tape is threaded through the grid from one roll to another and punched by hand, station by station.

With point-to-point locating speeds of 125 inches per minute a single-head machine will produce pieces at a rate 2½ times that of a manual drill press operation. However, it became apparent that more than the capacity of a single drill head could be used on the machine. The machine was therefore altered by adding another drill head and work holder and rewiring the control. It was then possible to do on one machine with one operator twice the production of a single-head machine.

Related Advances

The cutting problem was then attacked from the point of view of tape control. The cuts were, by design policy, all either parallel or perpendicular to the centerline of the board. It was decided that by reversing the interlocks it would be possible to keep the drill head down while the table was moving. Thus, with the proper cutting tool, the machine would cut a slot from point-to-point per the information from the tape reader. It was found to be impractical to use a routing cutter or milling cutter of less than ⅛-inch diameter on either manual or tape controlled operations in certain areas. That was why on manual operation the board was sent from the router to a band saw for the narrow cuts. With the tape controlled machine, the pieces requiring narrow cuts were moved to a clear area where a ⅛-inch cutter could be used.

Operations in drilling each chassis to receive the segments of the terminal board were also changed by the use of tape control. Under manual operation it was always necessary to match drill each chassis for its specific board segments and keep the segments identified with their chassis. The accuracy of the taped operation completely eliminates this matching and segregation by making all similar parts interchangeable. All of the rivet holes are programmed into one section of the control tape, and this section is used to make an inexpensive jig from a piece of epoxy board. The jig is used in the metal chassis to allow all chassis drilling and plating to be done without waiting for match drilling. The complete interchangeability of similar pieces assures accurate assembly.

As production techniques are developed, more possibilities open up. Nearing completion of development at Raytheon is equipment using the same Hillyer system for locating the curved aluminum chassis under a hopper-fed projection welding gun for welding ground terminals to the chassis.

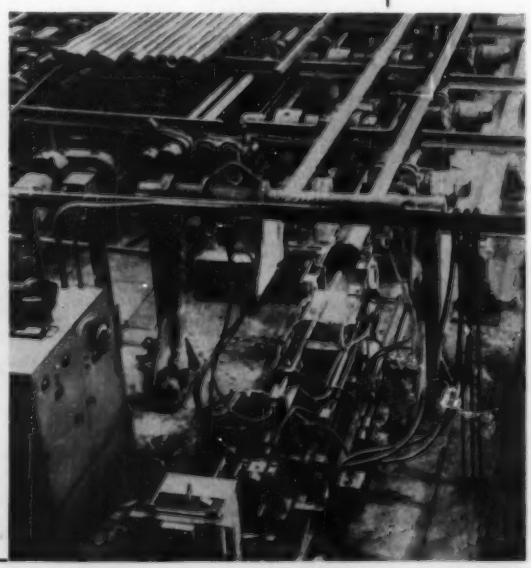
It is expected that the use of a turret drill, for changing hole size on command from the tape, will be incorporated in our next application. A method of divorcing the table drive from the control system except for feedback information is being investigated. This will allow the use of a greater number of work heads for the milling operation than is now feasible.

measuring pipe thickness

END SECTIONS of seamless pipe which fall below specified thickness are cropped off by Colorado Fuel & Iron Corp. To determine how much to crop from each end of a pipe, the wall thickness of the pipe must be measured. An x-ray unit built by Weston Instruments Div., Daystrom Inc. is used to measure and mark four lengths per minute.

The x-ray source unit and a probe tube pickup are mounted on a hydraulically operated carriage. Pipe to be gaged is moved onto motorized rolls in line with the x-ray carriage. The rolls rotate the pipe as the carriage moves forward.

A photoelectric unit senses the end of the pipe and activates the x-ray equipment. After the probe enters the pipe, a pencil beam of energy of fixed intensity is transmitted through the wall and detected by the probe. A marking device is automatically activated to spray paint on as much of the pipe end as is found to be less than specified thickness.



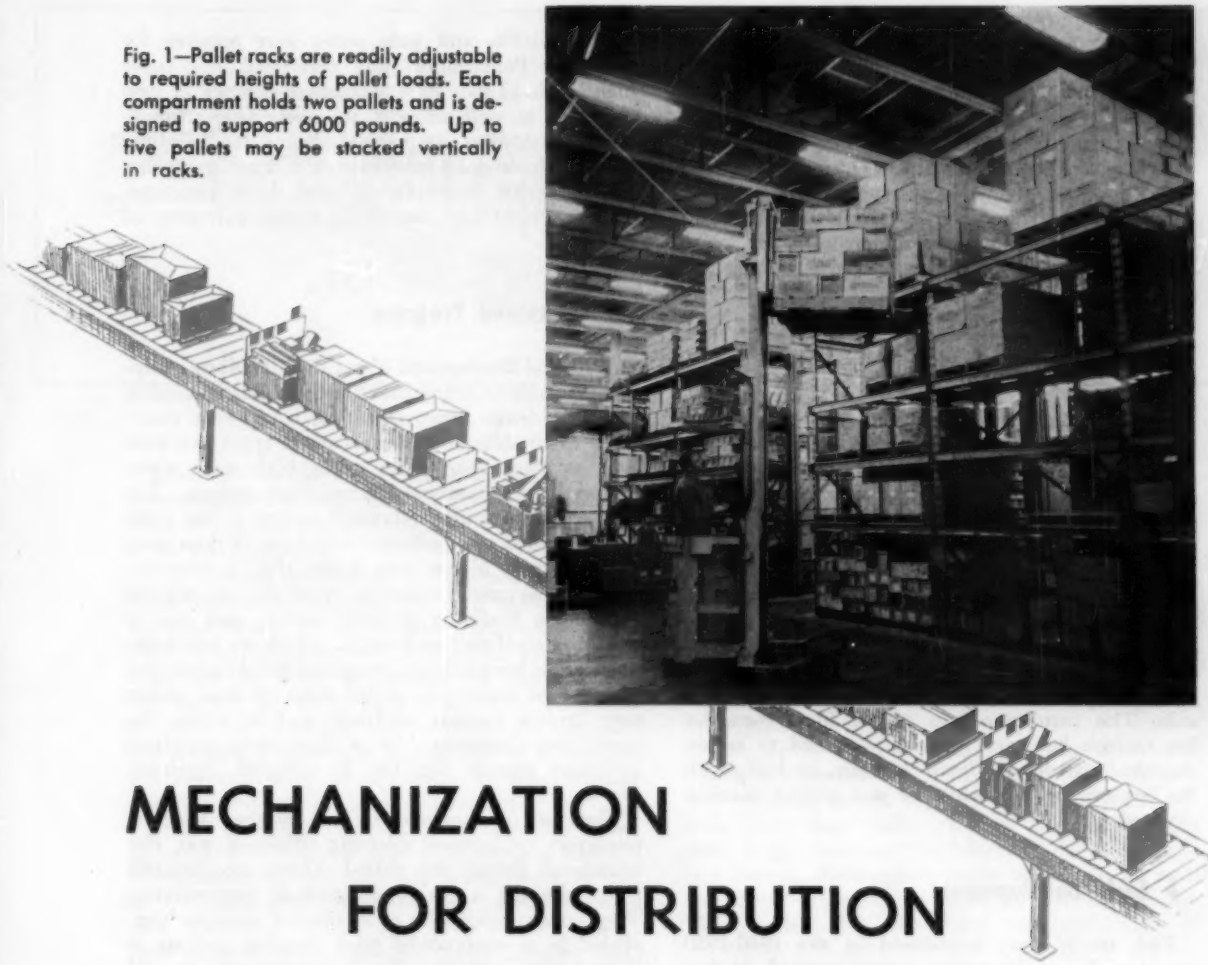


Fig. 1—Pallet racks are readily adjustable to required heights of pallet loads. Each compartment holds two pallets and is designed to support 6000 pounds. Up to five pallets may be stacked vertically in racks.

MECHANIZATION FOR DISTRIBUTION

Sorting operations for distribution of odd lot and volume items present some knotty handling problems. Successful methods outlined here contain some mighty useful ideas.

By EDWARD J. HARDY
Assistant Superintendent, Engineering Equipment Development, Telephone Sales Div., Western Electric Co. Inc., New York, N. Y.

BEST KNOWN as a manufacturer of telephone apparatus and installer of telephone equipment in telephone exchanges, Western Electric Co. Inc. has another very important function. As a member of the Bell System, it is charged with the distribution of most of the needs of associated telephone companies located throughout the country. These needs include not only telephone equipment made by the manufacturing division, but a myriad of other items including hardware, stationery and janitor supplies, batteries, etc., purchased from thousands of suppliers.

This article is based on a paper presented at "Fourth Conference on Manufacturing Automation" cosponsored by AUTOMATION, Purdue University, and Manufacturing Engineering Council, April 1960.

Currently there are 31 distribution centers, or Distributing Houses, located strategically near the centers of telephone activity for each associated telephone company. A typical House includes a repair shop to which all apparatus removed from service by a telephone company is returned for reconditioning or other disposition, and a warehouse which stocks from 8000 to 10,000 items in broken package or bulk shipment lots. An average warehouse ships 3000 items per day on up to 1800 separate requisitions within 24 hours after receipt of the order. A clerical group handles the stock maintenance, service, ordering, accounting, and billing functions associated with the repair and warehouse operations.

Because of the rapid growth in telephone usage throughout the country, particularly since World War II, our Distribution Organization has been and still is undergoing a tremendous expansion in facilities required to provide necessary service to the associated telephone companies. During this expansion period, a gradual transition has taken place from manual to mechanized methods. This transition will continue as better equipment is developed, with the dream of the future, of course, being push-button operation.

Pre-Automation Phase

In 1946, warehouse equipment consisted of two-wheel trucks, six-wheel flat trucks, six-wheel four-shelf trucks, skids, and skid trucks. Selections were made by touring the warehouse—usually with a shelf or flat truck—much like a housewife in a supermarket and selecting from broken packages, floor stocks, or bulk packages. It was a slow, tedious procedure which today's volume of business could not tolerate.

Single track conveyors for selecting broken package stock were installed in a few locations but were not particularly successful by modern standards. The requisition was placed in a container box on the belt, and each selector had to review the whole list for his items. Usually, he had to lift the box off the belt while he was getting material required.

Early Developments

Fork trucks were introduced in the 1946-1950 period, and material storage started upward. At that time, counterbalanced type trucks were the only kind available, and wide aisles were required for handling. Palletization was performed 2½ cubes high, with 13-foot high warehouse ceilings in new buildings as well as most old ones. This arrangement provided a mechanical means for handling material from dock to storage and some utilization on infrequent shipments of large bulk quantities. Thus, palletization resulted in better utilization of floor areas.

Continued Progress

With the development of material handling equipment capable of lifting pallet loads to greater heights, and with design improvements in trucks from cantilever to straddle and then to reach types, we were able to stack four pallet cubes high with warehouses having nominal 20-foot high ceilings. The new trucks permitted relatively narrow 7-foot aisles and permitted more efficient utilization of floor area.

Pallet racks of our own design, *Fig.* 1, were introduced because commercial types did not provide the height, flexibility of shelf location, and ease of changing shelf and rack height which we felt desirable. These were followed by special pallet racks—also of our own design—to bridge aisles, to store pallets over broken package shelving, and to utilize the space over conveyors. Use of these racks permitted increased storage facilities in crowded locations, *Fig.* 2.

The use of improved broken package selecting conveyors to increase selecting efficiency was also introduced during this period. These, too, are still going through a period of gradual improvement. They consist essentially of a powered conveyor paralleled by a nonpowered track running past six to eight selecting stations, *Fig.* 3. For convenience and efficient layout, the two tracks are looped back with

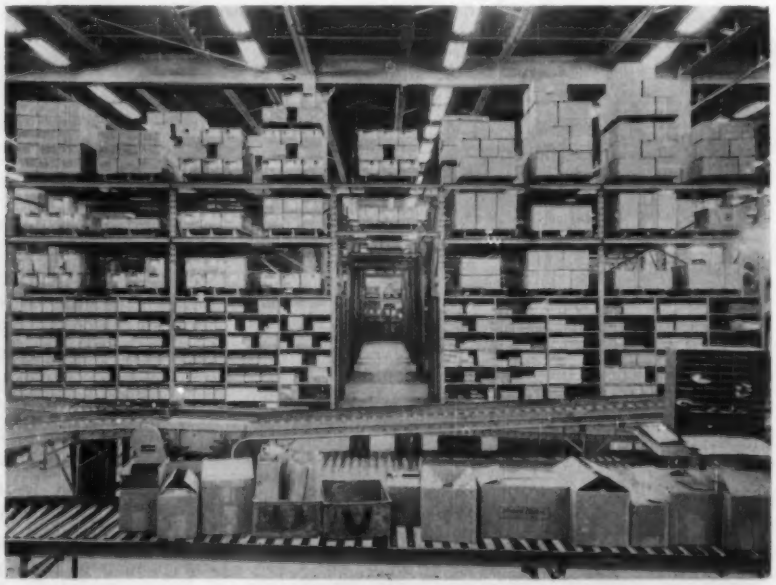


Fig. 2—Warehouse space is efficiently utilized by mounting pallet racks over commercial shelving and across service aisles. Space above conveyors is similarly used in other areas of building.

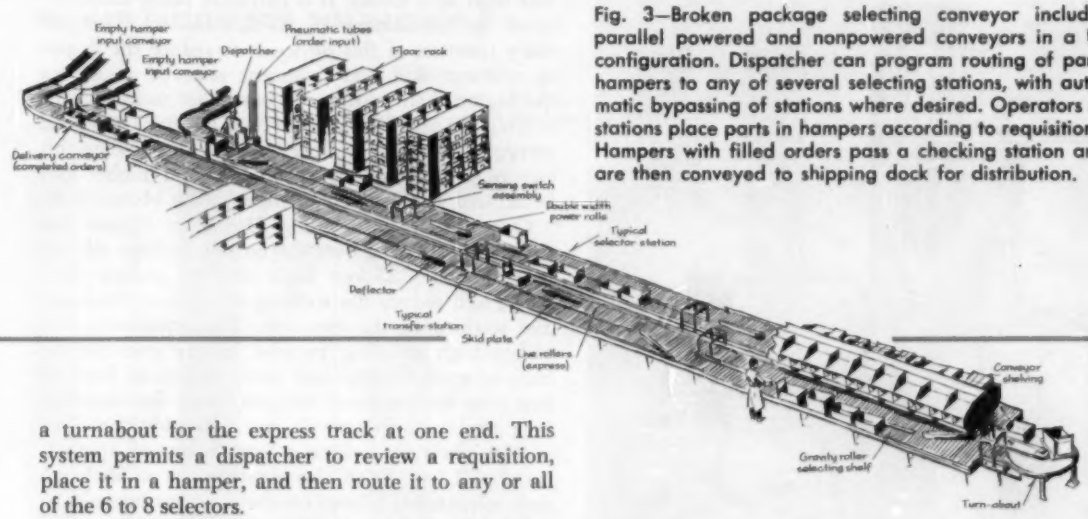


Fig. 3—Broken package selecting conveyor includes parallel powered and nonpowered conveyors in a U-configuration. Dispatcher can program routing of parts hampers to any of several selecting stations, with automatic bypassing of stations where desired. Operators at stations place parts in hampers according to requisitions. Hampers with filled orders pass a checking station and are then conveyed to shipping dock for distribution.

a turnabout for the express track at one end. This system permits a dispatcher to review a requisition, place it in a hamper, and then route it to any or all of the 6 to 8 selectors.

The hamper is conveyed on the powered express track. Automatic deflection to each position is determined by the dispatcher who receives his requisitions by a pneumatic tube system. As each selector completes his items he returns his hamper (plus any cartons added to form a train) to the power conveyor by pushing a button. When the last items are selected, the hamper is delivered to a checking position and then, by conveyor, to the telephone company shipping dock for distribution.

Where packing is required, the checker may deflect an order to a packing area. Hampers are returned to the dispatcher by a special return conveyor line. Several methods of controlling this system have been used. Currently, a removable flag which breaks a light beam to a photoelectric device is being used. The flags are automatically removed near the checking station and returned to the dispatcher.

This system requires that each selector have stock readily available. This is done by providing shelving over the conveyor for the most common items, broken package shelving at right angles to each position, and floor or pallet rack stacks.

Vertical storage by pallet racks introduced a problem of selection of larger items. The larger items which must be selected from pallet racks are stored in the first or second cubes as much as possible. However, due to space limitations some of the items must be stored in higher cubes. This involved calling for a power truck to get and return a pallet load after selection of the required item. To overcome this disadvantage, a high level selecting truck has been developed to accomplish this operation. The truck, illustrated in *Fig.* 4, permits a man to safely go up with a pallet, select material from a rack, place it on the pallet, and deliver the loaded pallet to a floor area. The truck may also be operated with the man and pallet in a raised position, although in the interest of safety this height is limited to 8 feet. The trucks can lift a man and pallet to a height of 16½ feet.

Another use for the trucks is in the reverse operation of storing (usually at the highest level available) certain items of material returned from the telephone company which must be held for indefinite periods of time and which cannot be conveniently handled as pallet loads. Two other functions for which this truck has been found very useful are taking inventories and maintaining high equipment.

The use of dragline trucks was also introduced during this period. These have been found to be a very efficient means of selecting larger units and bulk items from pallet rack or floor storage. In order to get maximum flexibility for rearrangements and growth, the dragline trucks are driven by mast and clevis arrangements from an overhead chain. The overhead drive does have the disadvantage of

Fig. 4—Selecting truck lifts a selector operator and a pallet so that operator can remove desired parts from pallets stored at high levels in racks and place them in pallet on truck. Platform controls enable operator to control horizontal movement of truck with platform elevated a maximum of 8 feet.

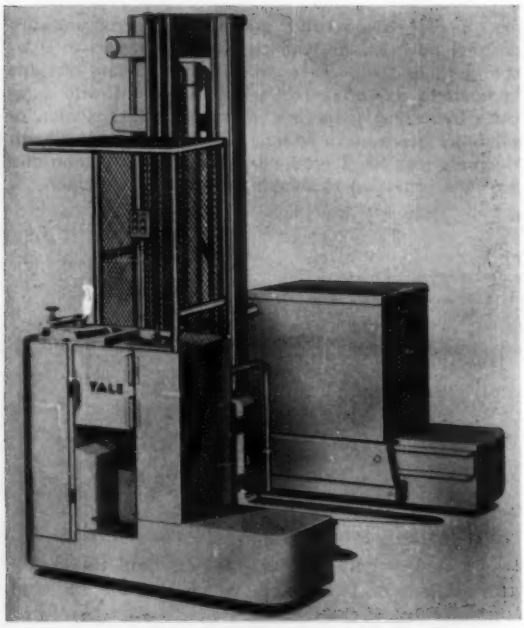


Fig. 5—Side-loading fork truck was built by Yale & Towne Mfg. Co. to Western Electric Co. Inc. specifications. Unit has 3000 pound capacity and uses a combination sliding mast and reach fork mechanism. Location of operator's position to one side of the mast improves visibility. Steering device permits turning all wheels 90 degrees to enable truck to move sideways toward a rack.

limiting the use of over-aisle pallet storage and requires care in power truck operation, but has operated successfully in our 20-foot ceiling, four pallet cube high buildings.

This second phase resulted in marked improvement in selecting time, manhours required, and in utilization of building floor space.

▶ Current Improvements

Further developments in trucks have permitted stacking to a fifth cube. As a result, our newest Distributing House building, as well as a major addition to one of our two remaining multistory buildings, has been built to provide a 25-foot warehouse ceiling. Our pallet racks have been increased in height to 18 feet, and we have had a new side-loading fork truck developed. This truck, *Fig.* 5, has several advantages over reach trucks, particularly at the 18-foot height: 1. A marked improvement in stability. 2. Increased lifting speed. 3. Much faster operating cycle due to elimination of the skill and accuracy required in turning, reaching, and placing or getting a pallet in or from a rack. 4. Improved visibility for the operator due to the operator's position being to the side instead of in back of the mast.

A new shelf-selecting device has been developed and tried as a model. It is currently being manufactured for installation on all side loaders. The primary function of this device is to reduce the degree of operator skill and judgment required to service the higher shelf positions in our pallet racks by controlling the operational cycle once the truck has been correctly positioned at floor level. By introducing this control, rack positions at 18 feet and higher can be utilized as effectively as those at the 14-foot level.

Our newest Distributing House in Illinois has triple deck shelving over the broken package selector to utilize the 25-foot high ceilings, reduce floor space, and reduce the walking distance of the selectors working at the conveyor. This equipment furnishes high shelving parallel to the conveyor in back of each selector and three shelves in front of him over the conveyor. Mounted over this shelving, in a structural framework, are two additional tiers of high shelving making a total height of approximately 22 feet. With this arrangement of shelving, each selector has a large number of items immediately available to him. Although only about 25 per cent of the total items stored in a high tiered unit are available to the selector at floor level, they represent from 85 to 90 per cent of the selections made. Thus, while the majority of items stored must be selected using auxiliary facilities, they represent only from 10 to 15 per cent of total selections.

Aside from making maximum utilization of vertical space, which has resulted in a saving of approximately 7000 square feet of floor space at Illinois, additional savings will also be made in the time required per unit selection.

The preceding information represents a resume of the mechanizing of our warehouses that has taken place since 1946. The improvements have not been uniformly installed at all locations, of course, due to limitations in the buildings, but have been included when new buildings or additions have been constructed. All installations are on a palletized basis, with heights depending upon ceilings available. The cost of the equipment required has been considerable, and mechanization without justifiable savings could never have been carried out.

Savings are expected from three principal sources:

TABLE 1—Merchandising Operations Comparison

(Average of all Distributing Houses)

	1946	1959
Stock sales volume (in $1000 per working day)	33	107
Number of stock items ordered per working day	1775	3053
Per cent of items ordered that are not delivered on schedule	11.1	2.0
Merchandising employees per $100,000 stock sales	1.01	0.52
Merchandising expense per $100,000 stock sales	4.51	4.49

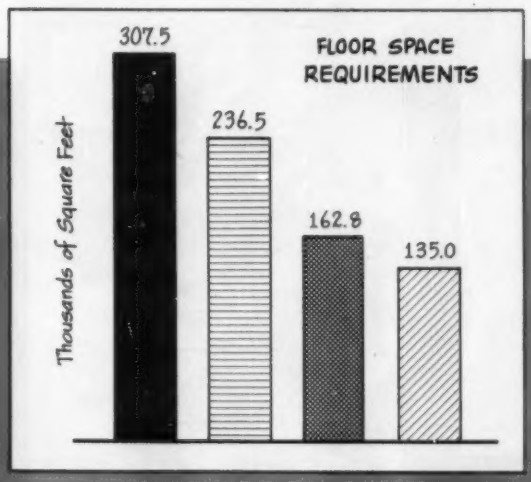


Fig. 6—Bar chart shows floor space requirements for Distributing Houses employing various storage and material handling techniques. Lefthand bar is for building using 1945 methods; righthand bar, representing a modern installation, requires 55 per cent less floor area for storage.

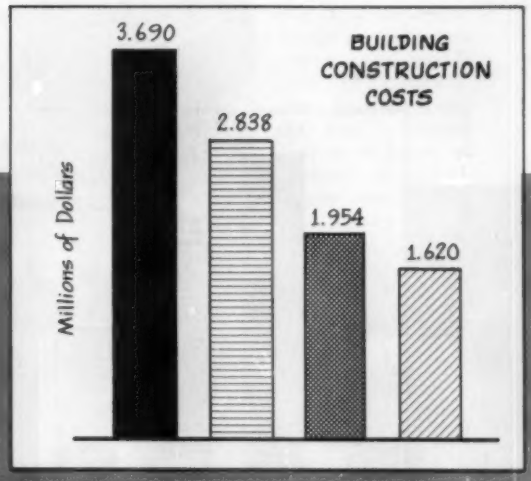


Fig. 7—Building construction costs are reduced as Distributing Houses employ more up-to-date storage and material handling methods. Cost of modern building, righthand bar, is 56 per cent less than that for 1945 type structure of equivalent capacity, lefthand bar.

LEGEND
- Floor storage
- Cantilever trucks and stacking 2½ pallet cubes high
- Straddle and reach trucks, stacking 4 pallet cubes high with narrow aisles, aisle bridging, pallet service shelving, and pallet rack service conveyors
- Triple tiered shelving, stacking 5 pallet cubes high, and placing dragline drive in the floor instead of overhead

Direct labor, building construction, and operating costs. Another result must be increased speed. As a service organization, we constantly strive to give the telephone company faster delivery of their needs.

A comparison of operations of our Distributing Houses in 1946 and in 1955 is shown in TABLE 1. The figures represent the average of all Distributing Houses. Stock sales have increased by 224 per cent, covering 73 per cent more items, while the number of merchandising employees has been cut approximately in half. The merchandising expense rate appears to be the same. However, when the increases in costs of salaries, equivalent rent, and other expense factors between 1946 and 1959 are considered, this must be accepted as representing a considerable cost reduction. Service has been improved mainly by the use of the broken package selecting conveyor and continuing improvements in its controls. The reduction in back orders is evidence of improved service.

Economics

In order to illustrate the effect of these mechanical improvements on buildings and building operations, the new Illinois Distributing House may be used as an example. Figures that will be quoted for floor space are based on statistical records accumulated over years of experience.

Floor Space Requirements. If, at the conclusion of World War II in 1945, we had been required to build a warehouse based on the present Illinois forecast of stations and base activity, we would have built a structure containing 307,500 square feet of storage space exclusive of the cable dock and excluding nonstorage space such as truck courts, maintenance areas, offices, and telephone company space.

By using cantilever trucks and by stacking 2½ pallet cubes high, the gross space has been reduced by 71,000 square feet, or 22 per cent, *Fig.* 6.

Introduction of straddle and reach trucks, stacking 4 pallet cubes high with narrow aisles, as well as the introduction of aisle bridging, pallet service shelving, and pallet rack service conveyors, further reduced the gross floor space by 73,700 square feet, representing another 25 per cent savings.

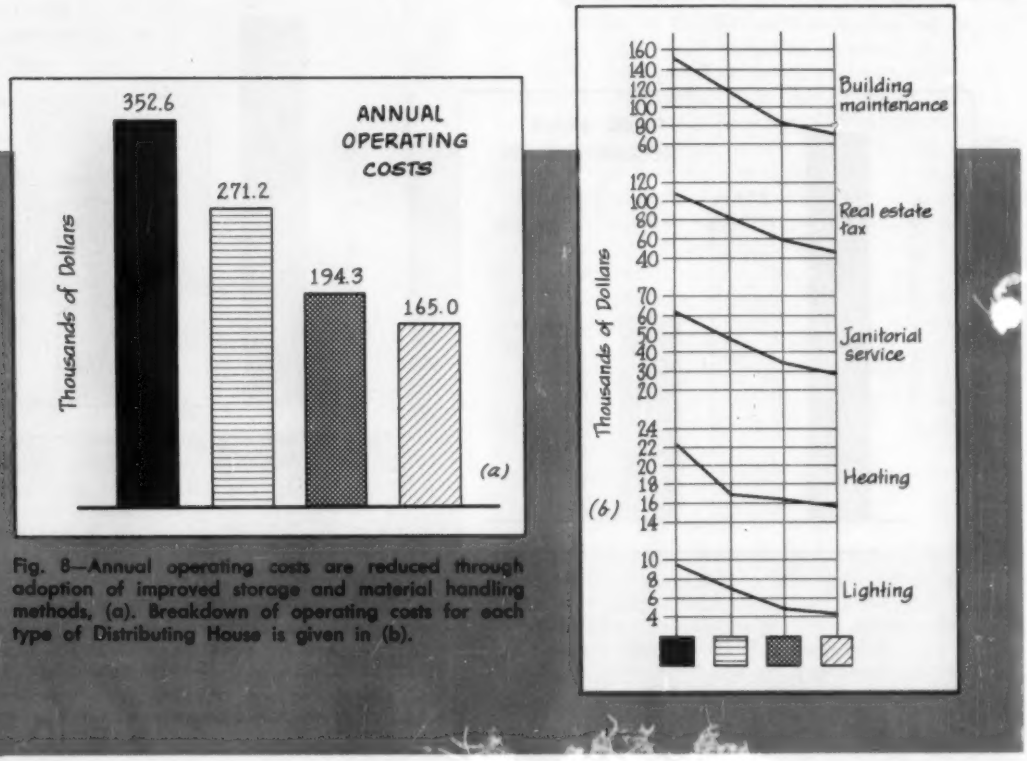


Fig. 8—Annual operating costs are reduced through adoption of improved storage and material handling methods, (a). Breakdown of operating costs for each type of Distributing House is given in (b).

The latest innovations included in the new Illinois House—such as triple-tiered selecting shelving, a fifth cube of pallet storage, and installation of the dragline drive in the floor (which permits bridging of the dragline aisles)—results in an additional reduction of the gross floor space by 27,800 square feet, or 8 per cent.

Building Construction Costs. Using current average Warehouse construction costs, the bar chart of *Fig.* 7 shows the savings that have been realized through more effective space utilization techniques and the introduction of improved storage equipment over the past ten years. The effect of each of the three improvements previously mentioned is an overall reduction in cost from $3.69 million to $1.62 million for the Illinois Distributing House, or a saving of 56 per cent.

Annual Operating Costs. In addition to the saving in original cost, a very appreciable saving has been realized in annual operating costs as a result of these equipment improvements. The reductions in building maintenance, real estate taxes, janitorial service, heating, and lighting are graphically illustrated in *Fig.* 8. These cost reductions represent a savings in the actual Illinois House of 53 per cent over the operating costs for a House employing 1945 handling methods.

These savings fully justify the equipment investment required and show the benefits of mechanizing warehouse operations. They also indicate the need for continued effort toward further improvements, and our design engineering is aimed toward making the equipment provided in each new building an improvement over that used previously. A fully automatic warehouse is, of course, our goal but our type of operation—requiring stocking of 8000 to 10,000 items ranging in size from tiny parts to telephone booths, switchboards, and reels of cable, and in any quantity from one to bulk packages—introduces complications not encountered in simpler warehouse operations. However, we are convinced that this goal can be reached on a gradual basis and are working on engineering developments toward this goal.

transactions available

The complete transactions of the "Fourth Conference on Manufacturing Automation" are printed in a 96 page booklet that can be obtained from AUTOMATION, Penton Building, Cleveland 13, Ohio for $2.00 per copy.

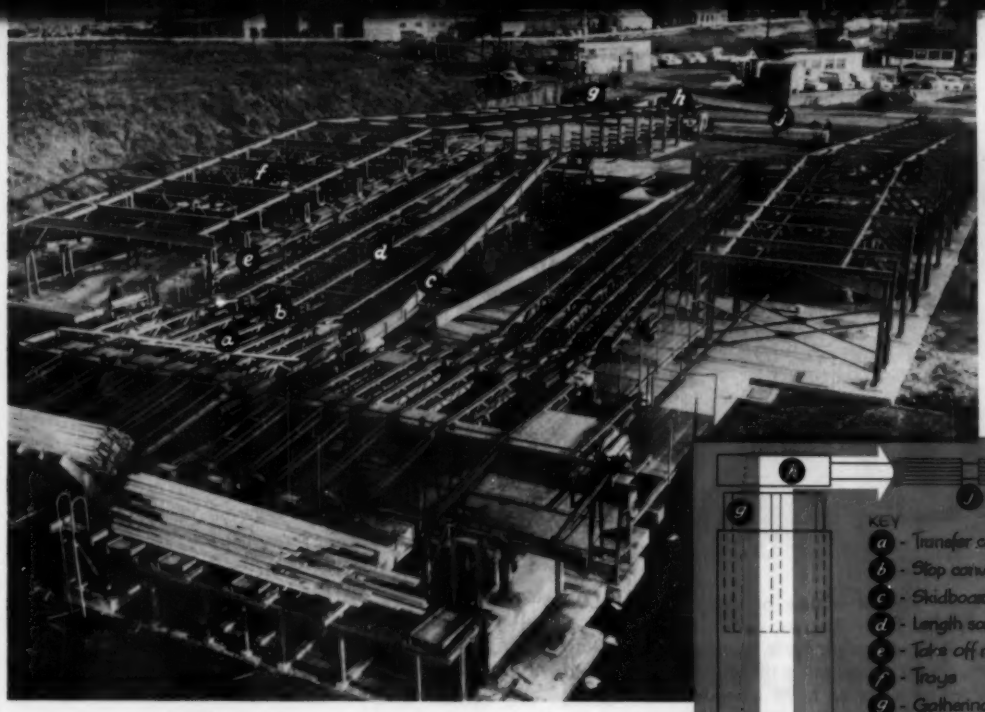
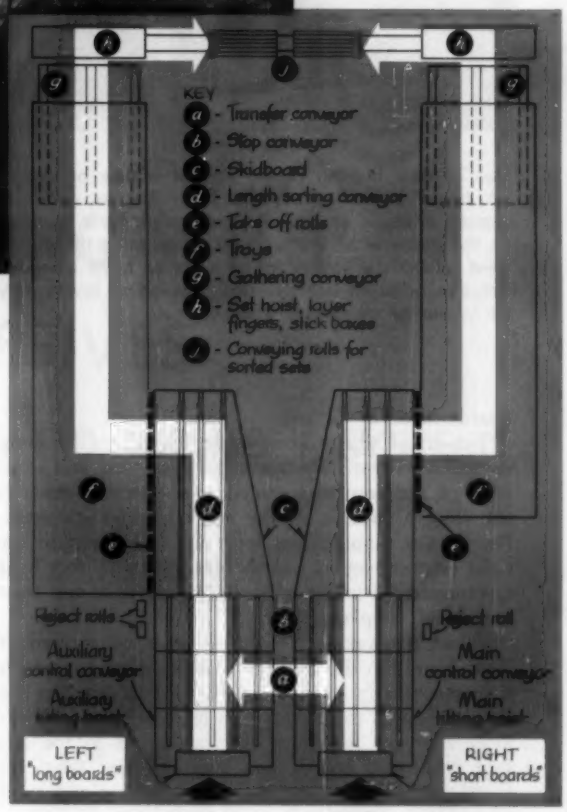


Fig. 1 — Automatic board sorting installation sorts boards into 17 classifications between 6 and 24 feet in length and forms stacks of boards of each length classification.



SORTING BOARDS BY LENGTH AUTOMATICALLY

AS RECEIVED from the producing mills, boards are frequently bundled in mixed lengths. For most users, bundles of uniform length are more desirable. A common problem in the lumber industry, therefore, is to sort boards from incoming bundles and regroup them in bundles of uniform length. In England this problem is being met with automatic equipment by Phoenix Timber Co. Ltd. In an installation designed and manufactured by B. & A. Engineering Co. Ltd. a team of 12 to 14 men perform a sorting job which would require at least 60 men with the usual mechanical aids.

The installation receives boards in bundles, sorts them into various length groups, and delivers bundles steel-strapped for shipment. The equipment can handle boards from 5 to 32 feet long, between 4 and 9 inches in width, and from 1½ to 3 inches thick. Depending on size and average length of boards involved, daily capacity is up to 25,000 cubic feet of lumber or as many as 28,000 boards.

The length sorting equipment is 240 feet long and 130 feet wide and is virtually two machines side-by-side. One side handles the longer boards and the other the shorter, with an arrangement to transfer boards from one side to the other. The equipment sorts boards between 6 and 24 feet in length into 17 different length groups and has two reject stations for 25 to 32-foot boards and one reject station for boards 5 feet long.

▶ Equipment Operation

Boards are fed to the equipment from either of two tilting hoists, *Fig.* 1. When one hoist is being reloaded with a stack of boards by a crane, boards from the other hoist are fed to the equipment so that continuity of flow is maintained. The tilting hoists are controlled by foot pedals and discharge

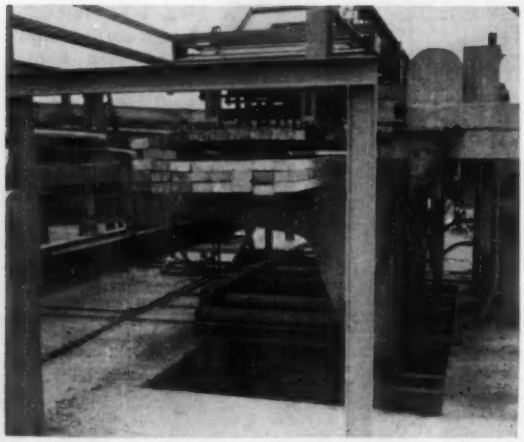


Fig. 2—View looking at the end of a new bundle or set being formed shows the layer fingers about to deposit a layer on top of layers already in position on the platform of the set hoist. Design of the equipment allows the layers to be solid or have air gaps between adjacent boards; and succeeding layers may be in-line or staggered when desired.

boards layer by layer.

The main tilting hoist feeds boards to the main control conveyor. By intermittent starting and stopping of the control conveyor, an operator controls the flow of boards to the right transfer conveyor. Boards less than 15 feet long are transferred to the right stop conveyor; boards more than 15 feet long are transferred to the left transfer conveyor and then to the left stop conveyor.

When the auxiliary tilting hoist is being used, it feeds boards to the auxiliary control conveyor which is intermittently started and stopped to regulate the flow of boards to the left transfer conveyor. Boards more than 15 feet long are transferred to the left stop conveyor; boards less than 15 feet long are transferred to the right transfer conveyor and then to the right stop conveyor.

From the stop conveyors on, the left and right sides of the installation are completely separate sections with identical elements. The right section handles boards less than 15 feet long; the left section, boards between 15 and 24 feet long. Each stop conveyor receives boards discharged by the transfer conveyors, squares them across the table, and controls the flow of boards to a length sorting conveyor. An operator supervises each stop conveyor and selects boards for removal by the reject rolls.

Each length sorting conveyor has a series of dogs which keeps the boards square across the conveyor. Only one board is fed between adjacent pairs of dogs. Because of the angle a skidboard makes with each length sorting conveyor, the boards gradually move across the length sorting conveyors as the conveyors carry the boards along.

When the ends of the boards project a preset distance from a length sorting conveyor, they contact power driven take-off rolls. These rolls transfer the boards lengthwise off the length sorting conveyor and into a tray corresponding to the length of the boards. Each tray consists of a pair of roller tracks parallel to the length sorting conveyor. The boards slide down the tracks and are collected against stops. An operator supervises release of boards by the stops to a gathering conveyor when enough boards of a given length have been collected for a new bundle or set.

The stop mechanisms are designed to release enough boards for a layer at predetermined intervals. The triggers are provided with adjustments to suit the thickness of board. The clamps which hold back the other boards in the tray while a layer is released have two positions. One position produces solid layers with no space between boards. The second position produces layers with 5 inches of space distributed between boards in the layer.

A full tray is manually selected on an electrical switch and an automatic timer is provided to control the spacing of layers on the gathering conveyor as a new set is begun.

Boards are carried a layer at a time to layer fingers which reciprocate to deposit layer after layer on top of a set hoist, *Fig.* 2.. The platform of the set hoist is automatically lowered between layers to receive the next layer.

After the first layer of a set reaches the layer fingers, an interlocking control regulates the release of layers from the tray. A batch counter, which is preset to the required number of layers in a set, stops the release of layers from the tray when the preset number is reached. Roller tracks are built into the layer fingers, and the gathering conveyor pushes each layer onto these rollers.

As a layer is positioned on the fingers, it initiates the retraction of the layer fingers. Boards are stripped off the fingers against stops so that they drop on top of the set being built on the set hoist platform. An interlock stops the gathering conveyor if a layer of boards arrives before the layer fingers are in position to receive it.

The stripping stops can be locked in position to produce solid straight-sided sets, or a drive can be engaged to produce a set with gapped layers staggered from 1½ to 3 inches with respect to the adjacent layers of the set. The layer fingers and set hoist are powered hydraulically under the control of solenoid valves. Limit switches on the motions involved step the units through their operating sequences.

Stick boxes are also provided which mechanically drop small sticks across the set between layers when required for air spaces needed in drying or to stabilize the layers. An operator controlling the set-making operation pulls a lever to initiate the stick-placing action.

After the new bundle or set is complete, power-driven conveying rolls transfer it lengthwise to a storage space to be steel-strapped, if necessary, and await removal by a fork-lift truck. The steel-strapping equipment was built by Signode Ltd. and automatically places steel straps around a set. The finished set is then transported to its destination.

In evaluating possible techniques for joining metallic and nonmetallic materials on a production line, careful consideration should be accorded to adhesive assembly. A variety of adhesives, application methods, and bonding equipment is available to the manufacturing engineer who is looking for a cost reducing method to join materials during assembly.

JOINING WITH ADHESIVES

IN AUTOMATED ASSEMBLY SYSTEMS

By J. W. JANSON
Technical Supervisor, Equipment & Applications
Adhesives, Coatings, and Sealers Div.
Minnesota Mining & Mfg. Co.
St. Paul, Minn.

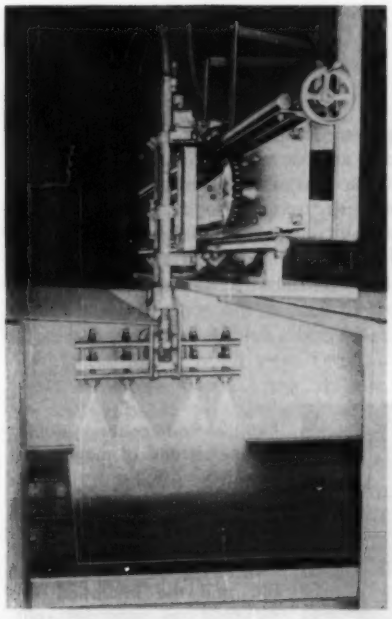


Fig. 1—Spray application equipment for applying one-component adhesives to flat panels provides a uniform film of material. It can be used with either structural or nonstructural adhesives. Similar spray equipment is available for applying two-component modified liquid epoxy adhesives.

MANY techniques are available to the manufacturing engineer for joining materials together on an assembly line. Some of the older techniques employ mechanical devices such as screws, rivets, or pins; a press operation such as curling or staking; or a process using heat such as welding, brazing, or soldering. To these older techniques has been added a new joining technique which is growing in prominence. This technique is adhesive bonding.

Adhesive bonding combines sealing, joining, and assembly in one production process. In a relatively simple operation that can be easily automated, adhesives can be used to join metal to metal; wood, plastic, or paper to metal; cement asbestos board to metal or plastic; honeycomb cores to metal or plastic; or many other combinations of materials. In many cases, adhesive bonding provides a means of joining components that would be impossible or impractical to join by other techniques.

Assembly by adhesive bonding methods provides many advantages. These include a uniform stress distribution over the joined areas, maintenance of integrity of assembled components, elimination of surface projections such as screw or rivet heads, and high resistance of the joints to fatigue. This manufacturing method also reduces assembly costs. Many industries that have replaced conventional assembly methods with adhesive bonding have realized cost saving resulting from simplified part design, fewer rejects, utilization of lower cost materials, and the elimina-

tion of extra operations such as hole drilling, close tolerance machining, and the need for 100 per cent inspection.

These factors, when coupled with relatively inexpensive automation techniques, will provide efficiency and cost savings. Like other automated processes, automated adhesive assembly will increase production, reduce part cost, and provide a controlled assembly method.

Adhesive Characteristics

A wide variety of adhesives, both nonstructural and structural, can be used in automated assembly operations. A list of the six major types of adhesives and their application characteristics is shown in TABLE 1.

Nonstructural adhesives are used in automatic adhesive assembly lines to make medium strength bonds. They are frequently modified elastomeric adhesives. Included in this class are contact bond adhesives which require only intimate contact to effect a bond. Most elastomeric adhesives require heat and/or pressure to effect a bond.

Structural adhesives are used to provide a high strength bond between metals and other structural materials. These adhesives are classified as phenolic-elastomeric liquid adhesives, phenolic-elastomeric film adhesives, and one-component and two-component modified liquid epoxy adhesives. All of these adhesives are supplied in a liquid form except for the film adhesives which are usually furnished in roll form and have controlled thickness and width. Film adhesives do not contain solvents, and their use eliminates drying problems and the disposal of fumes. They are usually thermosetting and require both heat and pressure to effect a bond.

One-component heat curing modified epoxy resin adhesives contain a latent hardener that is added to the formulation at the time of manufacture. The hardener is activated at elevated temperatures, making it necessary to expose the adhesive to a heat curing cycle to effect a cure. Only contact pressure is required during the cure cycle.

TABLE 1—Adhesives Used for Automated Assembly

Characteristics	Contact Bond
Type of Joint	Nonstructural
Form of Adhesive	Single liquid
Preparation For Use	None
Application Equipment	Spray gun, roll coater, pressure curtain, or flow gun
Curing or Drying Equipment	None
Curing or Drying Temperature	Ambient
Pressure Application Equipment	Contact pressure
Bonding Pressure	Nominal

Two-component modified epoxy adhesives consist of a base resin and a separate liquid catalyst or curing agent. The two materials are mixed in proper proportions prior to use. As soon as the two components are mixed, the curing reaction begins. These adhesives will cure at room temperatures under contact pressure. This characteristic makes them use-

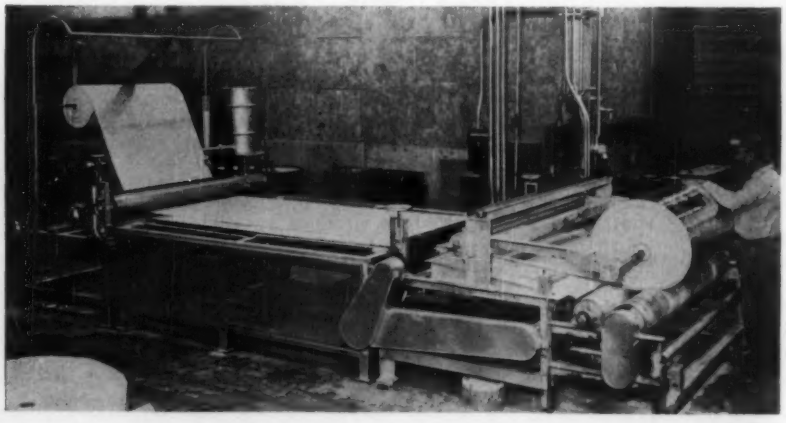


Fig. 2—Roll coating equipment (left end of machine) is used to apply a water dispersed modified elastomeric adhesive to aluminum foil before it is mated with ½-inch fiberglass insulation. The foil and the insulation are mounted on separate rolls. After adhesive is applied to the foil, the materials are brought together under a pressure roll and then wound on a core at the right end of the machine. The production rate is 65 to 90 linear feet per minute.

Modified Elastomeric	Phenolic-Elastomeric Liquid	Phenolic-Elastomeric Film	One-Component Modified Liquid Epoxy	Two-Component Modified Liquid Epoxy
Nonstructural	Structural	Structural	Structural	Structural
Single liquid	Single liquid	Dry film	Base resin and liquid hardener	Base resin and liquid catalyst
None	None	Cut to fit	None. Heat sensitive hardener added during manufacture	Mix catalyst during application
Spray gun, roll coater, pressure curtain, or flow gun	Spray gun, roll coater, pressure curtain, or flow gun	Manual or by die cutter and mechanical mechanisms	Flow gun, spray gun, or roll coater	Two-part mixing flow or spray gun
Infrared oven	Heated press, jigs, or fixtures[1]	Heated press or pressure fixture[1] in oven	Heated press or oven	None
160 to 225F	350F	350F	300 to 500F[2]	Ambient[3]
Roller or press	Press, jig, or fixture[1]	Press or fixture[1]	Contact during cure	Contact during cure
50 to 150 psi	150 psi	150 psi	Nominal	Nominal

1. Heat curing and pressure bonding can be combined into one operation or performed in separate steps.
2. Temperature depends on cure time. Cure time at 500 F is 1 to 2 minutes.
3. Cure requires approximately 6 to 24 hours at room temperature. Rapid cure can be obtained by heating assembly in an oven, under infrared lamps, or with dielectric or induction heating equipment.

ful for many high strength bonding operations where the application of heat is not feasible.

Since two-component adhesives require only contact pressure during the cure period, the need for elaborate and expensive jigs and fixtures is eliminated. The cure time at room temperature is approximately 6 to 24 hours, depending on the type of adhesive. Such adhesives are satisfactory for parts which will not be subjected to high stress during this period. However, a more rapid cure can be obtained by heating the assembled parts in an oven, under infrared lamps, or with dielectric or induction heating equipment.

Application Equipment

Basically, the equipment used for automated adhesive assembly lines consists of adhesive applicators, heat sources, and pressure sources. The equipment is combined in an adhesive bonding line, and assemblies to be bonded are transferred by devices such as conveyors. In some cases the automation line can be of a rotary type, and the parts can be indexed through the various bonding operations by a rotating table.

In general, adhesive application equipment includes automatic spray guns, flow guns, roll coaters, and pressure curtain adhesive applicators. Heat sources used in automation lines are usually in the form of ovens having hot air, steam, electrical, or infrared heat sources. In some instances dielectric or induction heating is used. Pressure sources include pinch rolls, platen presses, jigs, and fixtures. Depending on the components being bonded and the type of adhesive used, heat sources and/or pressure sources may not be required. If required, they can often be combined in a single piece of equipment or into one operation.

Automatic spray application equipment, *Fig.* 1, is generally used for applying adhesives to large flat or contoured sheets. Spray equipment is available for applying both one and two-part adhesives. By using automatic spray equipment, the uniformity of the spray applied film is far greater than with any manual method. The use of adhesives can be carefully established and maintained, and the rate of production is constant.

When adhesives are to be applied by spraying, a careful study of the shape and contour of the object should be made to determine exact gun positions and angles which will cover the surface quickly, most uniformly, and with the least amount of overlap or extension of spray pattern beyond the edges

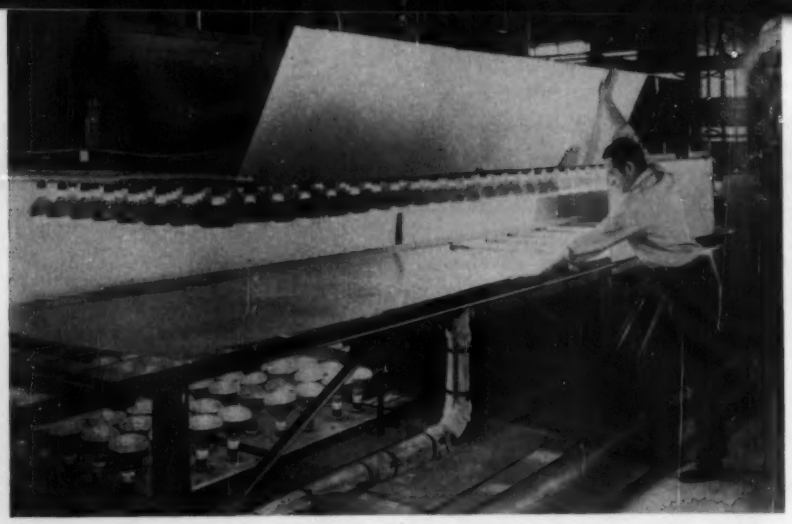


Fig. 3—In the manufacture of laminated panel assemblies, the lamination sections are spray coated with adhesive and then conveyed through an infrared light oven to build up the panel temperature so that the adhesive will be hot when the sections are assembled. This type of system is used to produce panel assemblies with outside facing of metal or plastic and inside cores of aluminum foil, hardboard, wood fiberboard, cement asbestos board, and gypsum board.

of the object. Horizontal straight line and contour and vertical straight line and contour automatic transverse spray equipment is used for applying adhesives to flat or curved parts in either the horizontal or vertical position.

To meet the need of spray applying two-part adhesives, a new and simple spray application machine that accurately proportions and completely mixes multiple part materials for continuous or intermittent production has been developed. This type of equipment can be integrated into a production line and permits the spray application of two-part adhesives such as the two-component modified epoxy resin base adhesives for bonding structural parts.

Pressure flow guns are easily cycled into an automatic bonding line. They are usually used on parts requiring straight line, circular bead, or drop-by-drop adhesive applications. For example, a flow gun application would be used when applying a circular bead of adhesive to a filter cap which is subsequently bonded to a filter element. In this case, the filter cap would rotate during adhesive application. Pressure flow equipment is available for applying two-component adhesives.

Roll coating equipment, *Fig.* 2, is used in high volume automated adhesive production lines to apply a uniform film of adhesive to flat parts and to honeycomb core material. Roll coating equipment is available with pumps to provide continuous circulation of the adhesives and with automatic controls for adding solvent to the adhesive to replace solvent lost through evaporation. This is sometimes necessary to maintain adhesive viscosity. Continuous circulation keeps adhesives mixed with proper proportions of solvent and base product. Various types of rolls are available for different adhesive applications.

Pressure curtain coaters apply adhesives by means of a uniform thin curtain of adhesive. Parts are conveyed through the adhesive curtain. Excess adhesive falls into an overflow chute and is recirculated through the machine. Coaters of this type can be used to apply both one and two-component adhesives. Like roll coating equipment, this equipment provides continuous circulation of the adhesive and can be equipped to replace evaporated solvent to maintain proper adhesive viscosity.

▶ Heat and Pressure Equipment

Ovens with various heat sources, such as infrared, electrical, hot air, and steam, are extensively used to cure or dry many types of adhesives. In general, indirect oven heating is relatively slow and inefficient when high temperatures are required for the curing operations. Ovens are excellent, however, for adhesive drying. Infrared ovens, *Fig.* 3, are appreciably more effective than circulating hot air ovens. Transfer of heat is quite rapid since parts

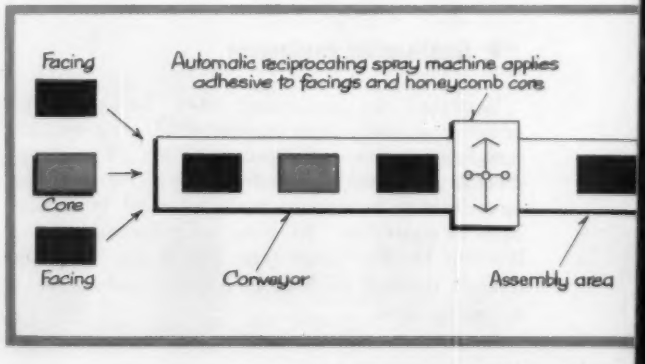


Fig. 4—Heat sources are not necessary for all panel assembly lines. The line shown uses a dry spray technique that removes most of the solvent during the application of adhesive. The facings and core can be assembled immediately after spraying. Pressure rolls complete the bonding process. The line also has been integrated with a paint finishing line so that raw materials flow into one end of the system and finished panels flow out of the other end.

are heated by the direct absorption of the rays.

The heat source and the pressure source can often be combined into one component to facilitate automation requirements such as heated press platens, jigs, and fixtures.

Dielectric heating is an extremely fast method of curing an adhesive, but is limited in use. The faces of the bonding jig are the electrodes between which the electric field is established. The heat results from the passage of a high energy electric field through a nonconductor. However, very thin adhesive films and possible voids in the adhesive, or unbalanced electrodes, will allow arc-through which breaks down the field. Consequently, at least one of the materials being bonded should be a nonconductor.

Steam heated platens of flat bed presses are characterized by rapid and well-controlled temperature rise. By proper valve arrangement, the use of water for rapid cooling is possible. Adhesives that require cooling before removing from fixtures can be utilized. Little time is wasted waiting for the platens to reheat for the next assembly.

Electric strip heaters can be attached to the face or to both sides of pressure fixtures or bars for curing long flat bond areas. For cylindrical joints, curved strip heaters that fit pressure devices for this type of part can be considered. If pressure is not a requirement, flexible tape heaters can be used by laying or wrapping them around the bond area.

A contoured matched die type of pressure fixture can be heated with cartridge-type heaters. Holes are drilled in the sides of the die close to the pressure surface. The cartridge heaters are then inserted. Accurate heat control is possible with thermostatic controls.

Constant pressure during curing operations is important. Two factors, the softening of the adhesive allowing squeeze-out and thermal expansion of the bonding fixture, can cause an appreciable drop in pressure. Consequently, pressure followup is necessary. This can be accomplished with hydraulic or pneumatic pressure equipment, spring loaded jigs and fixtures, etc.

When using cold setting adhesives, pinch rolls are excellent for applying pressure to flat assemblies and provide a constant pressure source. They are also applicable to conveyor-type production lines common with this type of adhesive bonding. Pressure is usually achieved by pneumatic, hydraulic, or spring sources. Pneumatic and hydraulic sources are used where high pressures are required, and springs are used when lower pressures are required.

▶ Adhesive Assembly Systems

Almost any adhesive assembly operation can be partially or fully mechanized by integrating the application, heating or curing, and pressure equipment into a production system. For example, a typical adhesive assembly system is the manufacture of sandwich panel assemblies in which a core is sealed between two outside panels.

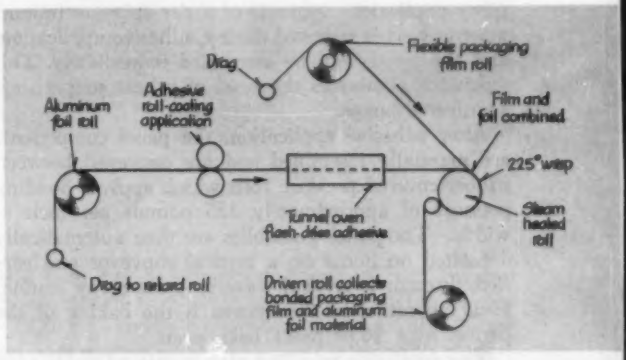
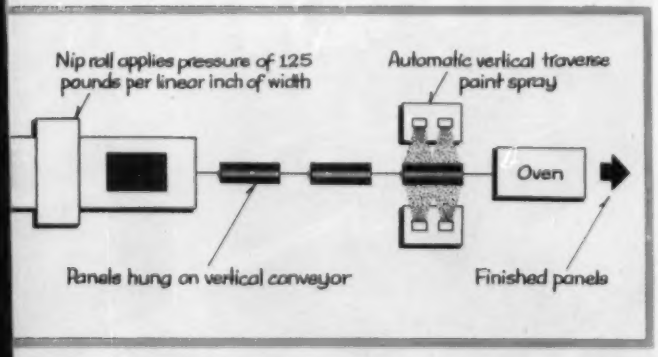


Fig. 5—A typical adhesive assembly line for web materials is shown. In this case aluminum foil is combined with a flexible packaging film. Heat sources for drying and curing the adhesive are required in this line. Other web assembly systems may or may not require heat sources, depending on the type materials being joined and the choice of adhesive used.

In this type of system, the outside panels and the core are placed on a conveyor and carried under a bank of infrared lamps to remove any moisture and to establish a uniform temperature for the components. The units are then conveyed to an automatic spray application station, such as shown in *Fig.* 1, where adhesive is applied. A modified elastomeric adhesive is usually used in this application for it has a rapid rate of strength buildup, high adhesion, high softening point, good sprayability, and excellent resistance to plastic flow.

After spraying, the materials are conveyed under another bank of infrared lamps to dry the adhesives and to build up the temperature so that the adhesive will be hot when the parts are assembled. The panels and core can be assembled either manually or with automatic turn-over mechanisms and positioning fixtures. After assembly, the sandwich panel assembly is conveyed between pressure rolls to insure intimate contact between the materials. Pres-


Nip roll applies pressure of 125 pounds per linear inch of width
Automatic vertical traverse paint spray
Oven
Panels hung on vertical conveyor
Finished panels

sure on the rolls should be adjustable and is generally set just below the crushing pressure of the weakest material being bonded. For example, when laminating soft wood fiberboard, pressure will be in the order of 50 pounds per inch of width. Sheet steel or aluminum assemblies will carry a pressure of about 200 pounds per inch of width.

In this type of system, the production rate is on the order of 120 sq ft of adhesive coated panels per minute. This amounts to 60 sq ft of completed laminate per minute since both surfaces are coated.

Another automated adhesive assembly line for honeycomb sandwich panel construction combines panel assembly with a panel painting operation, *Fig.* 4. Panels made on this type of line are used for such applications as table tops, secondary floor structures, and office partitions. The metal facings and paper honeycomb core material are placed on a conveyor and moved under an automatic reciprocating adhesive spray applicator. Because of a dry spray technique, most solvent is removed during adhesive application, and the panels can be assembled immediately. This technique eliminates the need of a heat source such as infrared lamps.

After adhesive application, the panel components are manually assembled and are conveyed between rubber covered pressure rolls which apply a bonding pressure of approximately 125 pounds per inch of width. The panel assemblies are then automatically deposited on hooks on a vertical conveyor and carried through a vertical traverse paint spray station. Final operation of the system is the baking of the panels in a 365F paint bake oven.

The sprayable modified elastomeric adhesive used in this application has exceptionally high heat resistance. This permits the paint bake cycle to be incorporated into the assembly line and eliminates the need for handling and storage between fabrication and finishing. Production rate for this type of line is approximately 5 linear feet per minute of finished panel.

Web materials can be assembled by a system such as diagrammed in *Fig.* 5. In this case a flexible packaging film is being bonded to aluminum foil. The foil is fed through roll coating applicators, and then the adhesive is flash dried in a tunnel oven. The two materials come together and are bonded on a steam heated combining roll. In other web assembly systems, a water dispersed modified elastomeric adhesive is used, and no heating is required to secure a bond. A system of this type is shown in *Fig.* 2.

The use of a rapid drying, short tack range adhesive has made possible an automatic process for bonding paper to formed aluminum strips in the production of corner beads for dry wall construction, *Fig.* 6. Corner beads consist of an aluminum strip that is formed to an angle of 90 degrees and faced with an adhesive bonded paper. The system shown forms flat strip into angle, cleans lint and fuzz from the paper and applies adhesive, combines the materials in a series of forming rolls, and cuts the finished strip into predetermined lengths.

Vinyl faced linoleum is bonded to painted metal panels on an automated adhesive bonding line. The units are used as floor panels in station wagons. The vinyl faced linoleum is fed to a roll coater where a modified elastomeric adhesive is automatically applied. The material is then conveyed to an assembly station which is approximately 40 feet away. During this interval, solvent evaporates from the adhesive.

Freshly painted steel panels are conveyed from paint bake ovens on a separate conveyor to the assembly station where the linoleum and panels are manually combined. The assemblies are conveyed through two banks of individual rubber rolls where a bonding pressure of approximately 16 pounds per inch of width is applied and then to a packaging station where the panels are packed for shipment. The adhesive application equipment is a roll coater enclosed in a cabinet which contains the solvent vapors. Because the adhesive used has high tack, fast strength buildup, and excellent air drying qualities, assemblies do not require high contact pressure or additional heat sources for satisfactory bonding.

▶ Structural Bonding

Bonding metal parts to form structural assemblies can be accomplished with automation techniques. For example, a system for applying a structural adhesive in film form to accomplish metal to metal

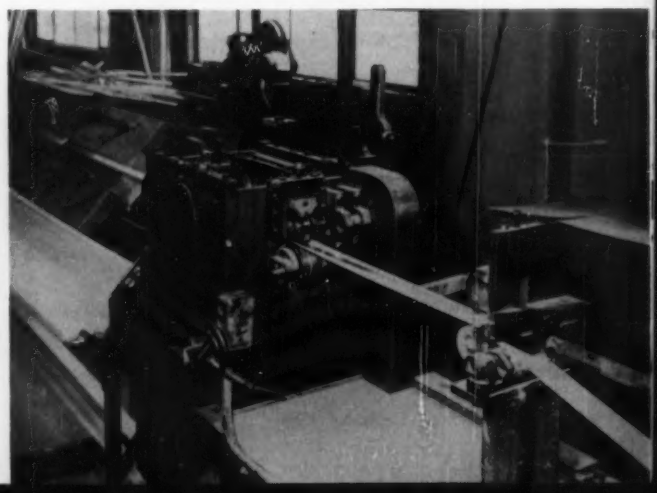


Fig. 6—System for making dry wall construction corner beads is shown. Flat aluminum strip is first drawn through a series of rolls which form it into a 90-degree angle. At the same time paper strip is cleaned of lint and fuzz by means of a scraper and vacuum nozzle and is passed under a special adhesive applicator. The coated paper is then guided through a series of pulleys until the adhesive has become sufficiently dry for proper bonding. The two materials are combined in a forming roll at the lower right and then drawn through a second series of rolls in the center of the picture which bond and form the paper to the aluminum angle. The finished corner beads are cut into predetermined lengths and stacked for shipment. Output of the line is approximately 5700 lineal feet of bead per hour.

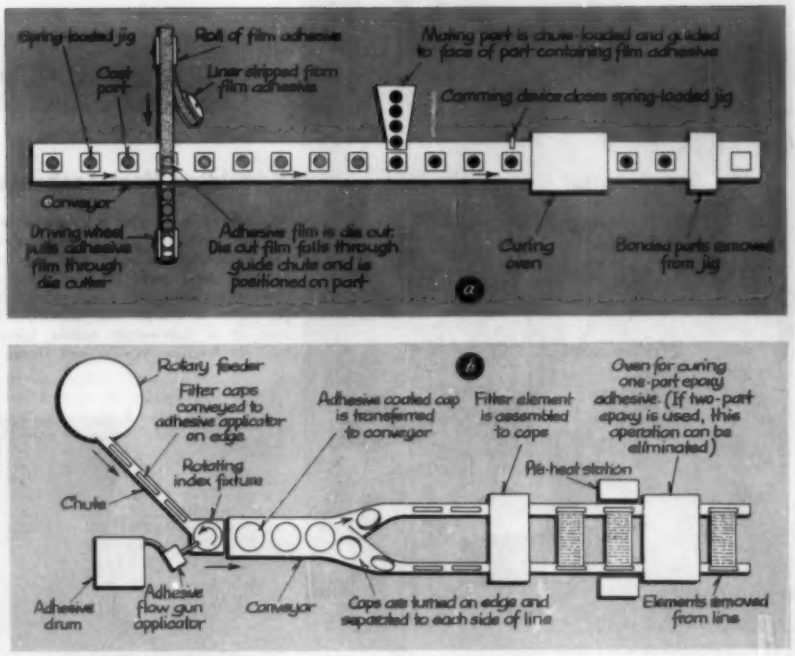

Spring-loaded jig
Roll of film adhesive
Mating part is chute-loaded and guided to face of part containing film adhesive
Cast part
Liner stripped from film adhesive
Camming device closes spring-loaded jig
Conveyor
Driving wheel pulls adhesive film through die cutter
Adhesive film is die cut. Die cut film falls through guide chute and is positioned on part
Curing oven
Bonded parts removed from jig
a
Rotary feeder
Filter caps conveyed to adhesive applicator on edge
Adhesive coated cap is transferred to conveyor
Filter element is assembled to caps
Oven for curing one-part epoxy adhesive. (If two-part epoxy is used, this operation can be eliminated)
Rotating index fixture
Pre-heat station
Chute
Adhesive drum
Adhesive flow gun applicator
Conveyor
Caps are turned on edge and separated to each side of line
Elements removed from line
b

Fig. 7—Sketches of two different types of adhesive assembly systems are shown. Dry film adhesive is die cut and applied to cast parts in the system shown in *(a)*. One-component modified epoxy resin adhesive is flow gun applied around the edges of filter caps and the caps assembled to filter elements in the system of sketch *(b)*.

bonding is shown in *Fig. 7a*. In an application of this type a roll of film adhesive is pulled by a driven reel through the adhesive application station of the line. A stripping device automatically removes a protective liner from the film adhesive.

In the application station the film is automatically die cut to fit the part shape. The parts are mounted in jigs and are indexed by a transfer mechanism under the die cutter. After the die cut film is loaded, the part is transferred to an assembly station where a mating part is positioned on top of the film and part. The assembled parts are then indexed to a pressure station where spring-loaded jigs are automatically closed by means of camming devices or pneumatic or hydraulic actuated mechanisms.

The springs in the pressure jigs provide follow-up pressure and automatically compensate for pressure loss due to thermal expansion and adhesive flow out. The jigs are then indexed through a heat source for adhesive curing operations. After curing, the pressure device is unlocked and the assemblies are either manually or automatically removed from the line.

Another structural application is shown in *Fig. 7b*. In this case, filter caps are bonded to metallic filter elements. Either a one-component or a two-component modified epoxy resin adhesive can be used for this type of application.

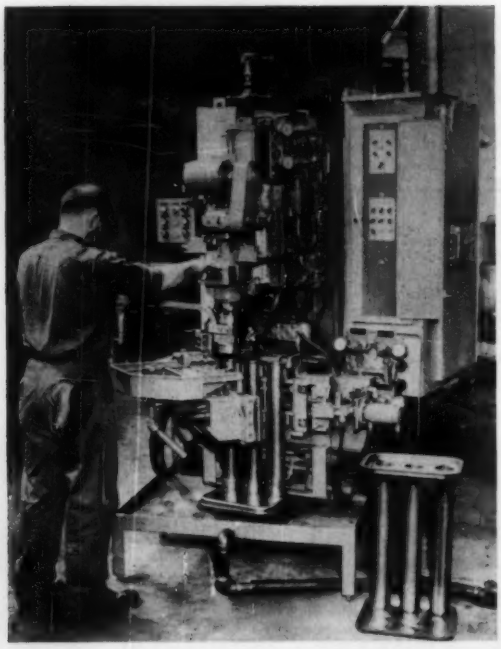
Filter caps are automatically fed on edge from a rotary feeder to a rotating indexing fixture for adhesive application. The adhesive is applied by a flow gun around the edge of the cap as the part rotates. If a two-component adhesive is used, the flow gun application equipment must accurately proportion and completely mix the two-component materials. When the adhesion application is completed, the flow gun automatically shuts off, and the cap is air ejected to a conveyor line.

The caps are then alternately separated and turned on edge as they are conveyed to the assembly station. At this point a metallic filter element is fed between two end caps to complete the assembly. Only contact pressure is required to effect a bond if either a one-component of a two-component adhesive is used. However, if a one-component adhesive is used, the assembly requires a heat cure and must be passed through a heat source. To reduce curing time, a preheat operation is often performed on the assembly prior to the oven curing operation. This operation could be accomplished by induction coil heating. Two-component adhesives do not require a curing operation, and the assembly is complete as soon as the caps and filter element are pressed together.

▶ Future of Adhesives

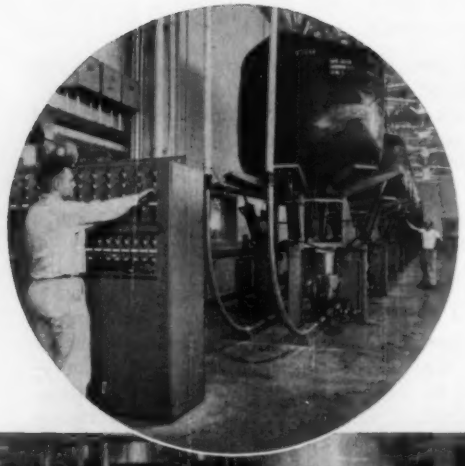
At the present time the two-component modified liquid epoxy adhesive is the most attractive adhesive for automated assembly lines since it does not require heat and pressure equipment to complete the bonding process. However, the necessity of mixing the base resin with a catalyst at the time of use is not ideal. More versatile adhesives are constantly being developed and tested in research laboratories. Eventually, an ideal one-component adhesive will be marketed that will have all the desirable properties of two-component adhesives, can be applied as received, and will set quickly without heat or pressure. When this development occurs, adhesive bonding will become a major technique for joining parts on automated assembly lines.

automation



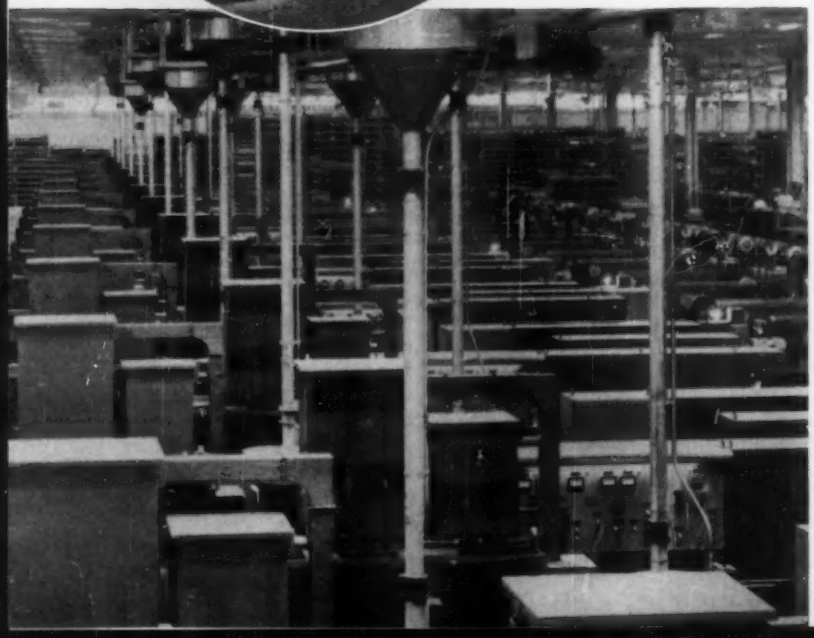
Welding Heat Exchangers

WELDER equipped with a unique wobble head is used by Motor Wheel Corp., Lansing, Mich., to join 3-inch diameter thin-walled tubing to end panels of 20-gage aluminized mild steel. The wobble head is shaped like a cup. An eccentric drive rocks the cup electrode around the periphery of the weld, rotating on edge with a rolling motion. The resulting weld is fast, clean, and gas tight. A welded heat exchanger unit is shown at the lower right and is used in a light-weight mobile home furnace. The welding equipment was built by Precision Welder and Flexopress Corp.



Casting Aluminum Billets

TWENTY-FOUR aluminum billets are cast at one time by this casting machine installed in the California plant of Michael Flynn Mfg. Co. Each billet is cast vertically and is 6 inches in diameter by 20 feet in length. The machine features an exclusive mold design and an automatic metal flow control. Output of the machine is over 20,000 pounds of aluminum billets per hour. The machine was built by Lobeck Casting Processes Inc.



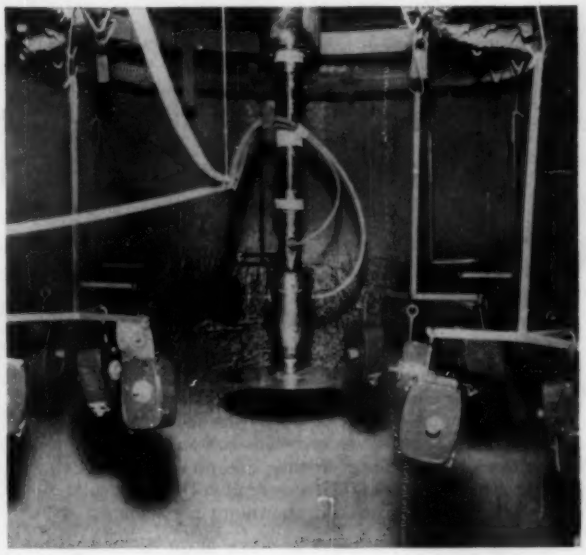
Conveying Plastic Pellets

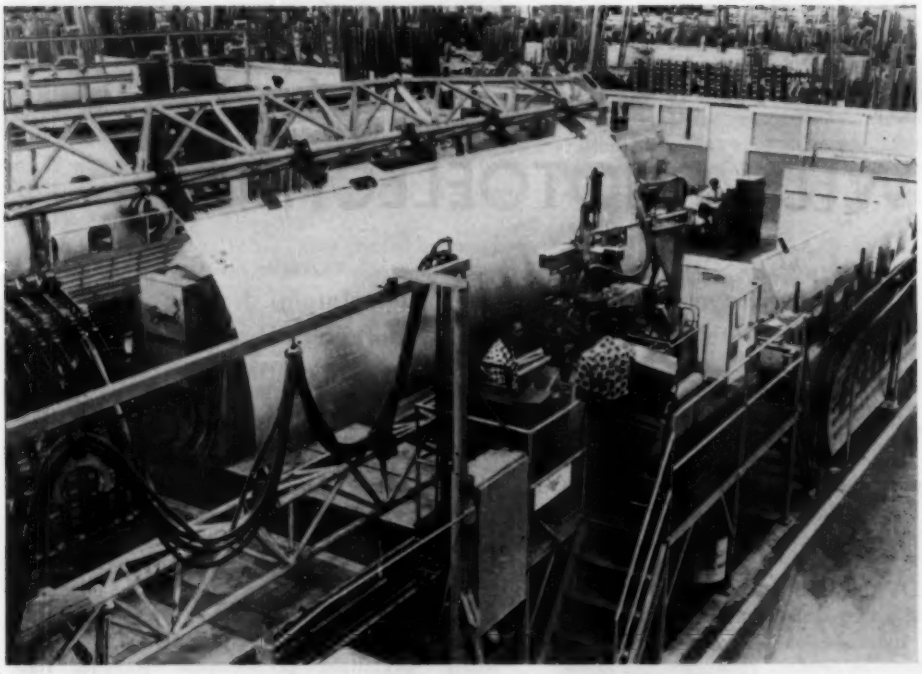
EXTENSIVE air conveying system is used at the Omaha, Neb., Works of Western Electric Co. Inc. to unload plastic pellets from collapsible rubber shipping containers and to deliver the pellets directly to 61 extrusion stations in four separate processing areas. System distributes approximately 2225 pounds of pellets per hour. Inset shows a control panel and a battery of 12 shipping container cradles that feed plastic pellets to some of the 42 extrusion stations in the insulating area, shown in the main view. Other control panels and cradle units service the remaining stations in this area and the other three processing areas. System shown can be programmed by patch cords to deliver any of 10 colors of pellets to selected extrusion stations. Main pneumatic conveyor lines running beneath cradles are fed and deliver pellets to extrusion area. Air-operated diverter valves automatically direct pellet flow from main conveyor lines to proper extruder storage bin. When bin is filled, valve closes and pellet flow continues to diverter valve for another extruder running same color. A pellet flow of a different color may follow in the same conveyor line without danger of mixing with preceding flow. The air conveying equipment for the system was provided by Dracco Div., Fuller Co.

in action

Painting Camera Cases

ELECTROSTATIC spray painting equipment provided by Ransburg Electro-Coating Corp. is used at Keystone Camera Co. Inc., Boston, to apply wrinkle finish paint to camera cases. The cases are degreased, etched, and rinsed prior to delivery to the finishing department. Upon receipt, the parts are loaded onto hangers and conveyed past two successive reciprocating disk-type atomizers which build up a coat of wrinkle material. The atomizers are separated by sufficient distance to allow adequate flash-off of volatile material between paint applications. The cases are then conveyed past a bank of infrared lamps which sets up the wrinkle finish on the parts. After baking in a gas-fired convection oven, the cases enter a cooling leg of the conveyor, and then are unloaded and inspected. A similarly equipped finishing line is used for projector cases. Both camera and projector cases are processed in several different color combinations, and color changes may be made 6 to 8 times per shift. However, less than 5 minutes are usually required to switch a line from one color to another.





Riveting Fuselage Panels

TAPE controlled riveting machine installed at the Long Beach, Calif., assembly plant of Douglas Aircraft Co. Inc. is used to automatically rivet 31-foot long fuselage panels for DC-8 Jetliners. The panels are held in a 40-foot long tooling frame which travels along a 90-foot floor track during riveting. Tack rivets located at five foot intervals are used as tape-to-panel synchronizing points when the machine is operating under automatic control. Since the operator at the control panel cannot see the rivet ram behind the panel, a closed circuit television system, employing two cameras and two monitors, permits the operator to check the alignment of the ram with the tack rivets and to manually adjust the worktable position if necessary. Each camera transmits a target reticle to its associated monitor. In the synchronization process, the machine is manipulated so that the target reticle is aligned over the tack rivet. During automatic operation, the operator can continuously check machine alignment via the camera setup. The riveting machine was built by General Electro Mechanical Corp., and the television system was provided by TelAutovision Closed Circuit TV, Div., TelAutograph Corp.

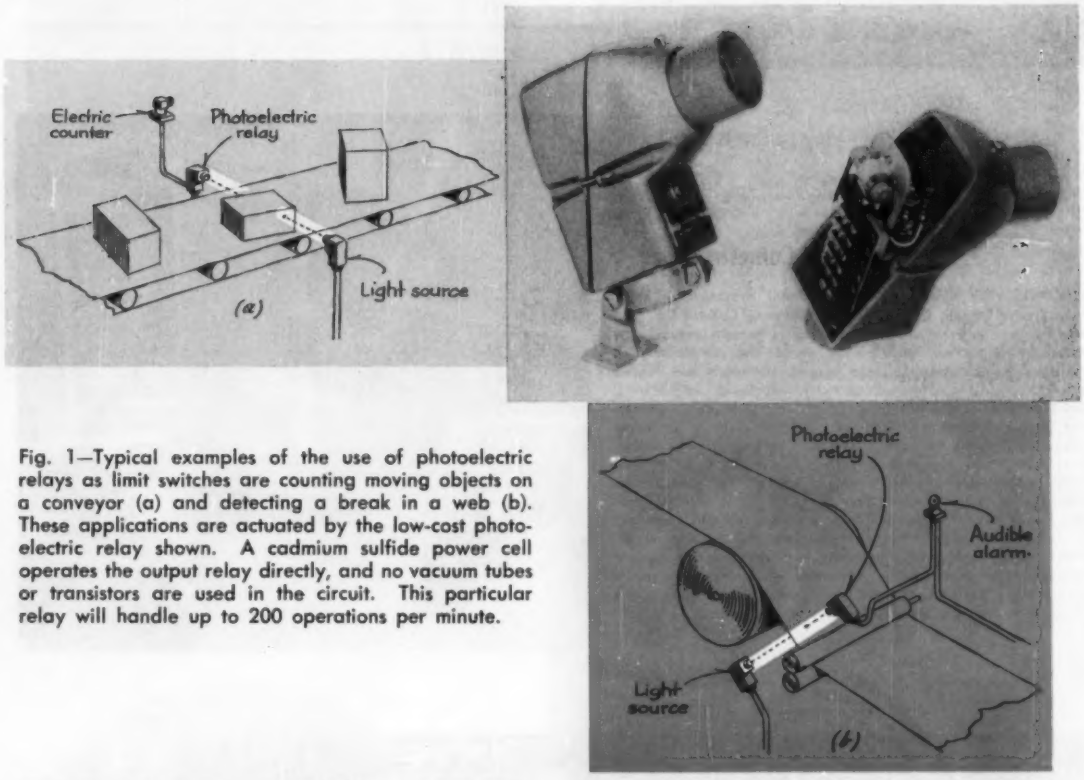


Fig. 1—Typical examples of the use of photoelectric relays as limit switches are counting moving objects on a conveyor (a) and detecting a break in a web (b). These applications are actuated by the low-cost photoelectric relay shown. A cadmium sulfide power cell operates the output relay directly, and no vacuum tubes or transistors are used in the circuit. This particular relay will handle up to 200 operations per minute.

DOING THE JOB WITH PHOTOELECTRICS

Photoelectric controls have reached a high state of development today. Use for jobs from simple on-off control to complex code recognition provides a range of automatic operation that challenges the imagination.

By **JOHN J. LAREW,** Unit Manager, Engineering Section, Specialty Control Dept., General Electric Co., Waynesboro, Va.

THE RAPID ADVANCE in electronic technology in the past three decades is clearly demonstrated in the field of photoelectric control. Steady improvement in product reliability has gradually changed industry's reluctance to accept electronic devices into an eagerness to make any application which is economically and technically sound. Photoelectric controls were once applied only as a last resort or as a "magic eye" novelty. Today, these systems are chosen for their special characteristics, which in many cases make them the best, if not the only solution to the problem.

Many specialized photoelectric controls have evolved in answer to the question "can a standard photoelectric relay be made to do this job?" Generally, an affirmative answer results in an application of a standard "off the shelf" photoelectric relay. As requirements become more stringent, it is often necessary to refine the device into more specialized equipment. Therefore, to properly apply this control technique, it is important to understand the capabilities and limitations of photoelectric control.

This article is based on a paper presented at "Fourth Conference on Manufacturing Automation" cosponsored by AUTOMATION, Purdue University, and Manufacturing Engineering Council, April 1960.

▶ Pros and Cons

Optical sensing systems have many uniquely attractive features, some of which are listed below:

1. Light beams do not exert any force on the objects they intercept.
2. A light beam can span a distance of many feet and still respond to an interruption anywhere along its path.
3. Light beams have no inertia, permitting high speed operation.
4. Infrared light, used for some installations, is invisible.
5. Light beams can readily sense smoke, fog, or other materials which cannot easily be made to operate mechanical devices.
6. Phototubes can be made to respond to printed marks, color differences, and other qualities which can only be sensed optically.
7. Ease of magnification by simple lenses, and highly sensitive detectors, facilitate the design of systems with extremely high sensitivity.
8. Light beams do not wear when in contact with rough, high speed objects.
9. In tight spots the detector and light source may often be mounted outside the area of critical space requirements.
10. Light travels in perfectly straight lines.

As with any control system, there are certain limitations in the photoelectric approach, some of which are listed below. Careful consideration of these limitations will result in reliable system performance.

1. High ambient light, especially sunlight, may tend to to override the signal.
2. Highly polished surfaces in the presence of high ambient light may cause false operation by reflection (especially true of moving vehicles out of doors).
3. Lamp filaments eventually burn out, even when operated at low voltages.
4. Photocells are "color blind." They respond best to some particular color, but the ability to distinguish color must be specifically designed into a system.
5. A 10 per cent line voltage change results in approximately 35 per cent light change from a filamentary lamp; thus systems must be able to operate with considerable light source intensity variation, or the supply voltage must be regulated.
6. Most photocells cannot stand high ambient temperatures.

▶ Application As Limit Switch

One of the earliest and still one of the most common applications of photoelectric relays is counting moving objects on a conveyor, *Fig.* 1*a*. An ordinary limit switch could do the same job if the packages did not vary in size and orientation. Even with these variations, it is possible to use several limit switches spaced across a strip and operated in parallel if space permits. Generally, it is much easier to mount a single low-cost photoelectric relay in a convenient location so that packages of any height or location on the conveyor will interrupt the beam.

Another limit switch type of application for photoelectric relays is protection against web breaks. The objective is usually to shut down a machine if a paper web or metal strip breaks. A photoelectric beam positioned above the web, *Fig.* 1*b*, does not interfere with threading operations, cannot mar delicate webs, and is not harmed by welds or other discontinuities in metal strip. A small self-contained photoelectric relay is suitable for conveyor counting or web break detection.

Photoelectric intruder detection may replace or supplement fences to give more positive protection. A fence may discourage intruders, but cannot give absolute assurance that it will not be crossed. An invisible infrared light beam inside the fence can sound an alarm when it is broken and floodlight an area. Systems of this type usually employ modulated light sources and tuned receiving units to permit operation up to one-half mile, even in daylight. Such systems are almost fail-safe, since they respond only to the frequency of the modulated light source. Failure of the lamp or any other part of the system gives a signal equivalent to breaking the beam. Such systems may be tripped accidentally by fog, other adverse weather, birds, or blowing papers.

There are countless other limit switch types of applications for photoelectric control. Such applications are more or less selfevident, and control systems are easily designed and installed to cover them.

▶ Inspection Applications

Although a majority of photoelectric relay applications are probably of the simple limit switch type, there are many cases where an equally simple system

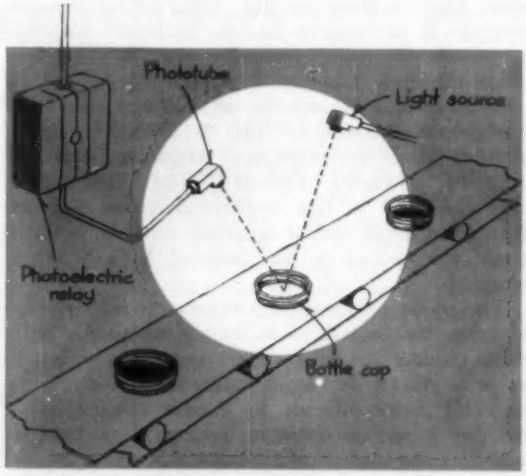


Fig. 2—A simple inspection job that can be done with a photoelectric relay is sensing for the presence or absence of a paper liner in a metal bottle cap. When liners are present, the light beam is not reflected. However, when a liner is missing, the light beam is reflected to the phototube, causing the relay to actuate and stop the conveyor belt or sound an alarm.

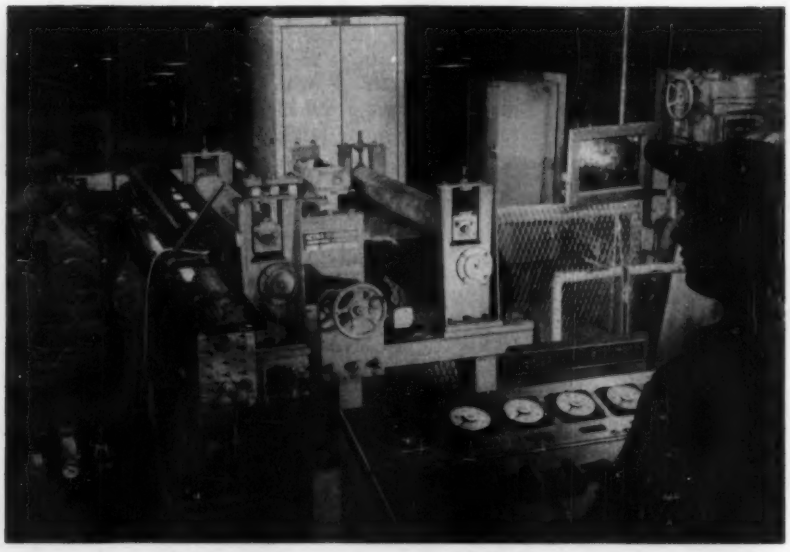


Fig. 3—Photoelectric equipment installed on a shear line at Jones and Laughlin Steel Corp. inspects tinplated steel strip for small pinholes. A bright lamp shines down on the moving strip. Beneath the strip are a series of sensitive photomultiplier tubes located in a shielded enclosure. Light passing through a pinhole causes one of a number of photomultiplier tubes to actuate a relay which can be used to operate devices for marking the strip or counting the number of faults in a specified area.

may relieve an operator of a boring inspection task. For example, in the case of inspection for presence or absence of a paper liner in a metal bottle cap, a photoelectric relay can readily sense the absence of the paper and reject the cap, *Fig.* 2. A number of other similar jobs can be done well by simple photoelectric relays. Inspection for absence of paint, upside down condition, missing parts in an automatic progressive manufacturing cycle, etc., requires only very simple equipment.

The next level of inspection may still be of the *Go No-Go* variety, but may require highly specialized equipment. For example, a pinhole detector, *Fig.* 3, employs photoelectric techniques to inspect tinplated steel strip used in making food cans. Strip with very small holes must be rejected since a single can of spoiled food in a case could result in damage to the labels of many other cans. The tinplate strip is sometimes inspected at speeds as high as 4000 feet per minute for holes as small as 0.001 inch in diameter. A 2500- watt lamp illuminates the strip from the top. Light falling through pinholes in the strip is detected by highly sensitive photomultiplier tubes located in an enclosure beneath the strip. Light must be carefully shielded to prevent leakage around the edges of the strip into the detection chamber. This is done by rugged shutters which are maintained in contact with the strip by pneumatic cylinders. The photoelectric approach used in this application makes possible high speed inspection for extremely small holes. This type of inspection is not practical by any other means.

The pinhole detector, sensitive as it is, performs a rather simple task of indicating whether a hole exists or does not exist. Many inspection tasks involve a greater degree of judgment and are considerably more difficult to inspect automatically. Another inspection operation performed on tinplate will illustrate this. Surface inspection of tinplate is necessary to reject material containing poor plating, scratches, spots, and other blemishes. Human beings can glance at a strip and decide to pass or reject it. In doing this, certain defects will always cause rejection, while others will be considered as to degree and whether or not they occur in combination with other defects.

A tinplate surface inspector, *Fig.* 4, was developed by the General Electric Co. for evaluation by the United States Steel Corp. This equipment uses image dissector tubes to rapidly scan the surface of the material. At any one instant, each tube is "looking" at only one elemental spot on the surface. The amount of light reflected from this spot is a function of the condition of the surface. Any flaw, such as missing tinplate, dents, welds, or oil spots, results in a decrease in light and a corresponding reduction in the electrical signal. As the strip moves under the detection station, the point of inspection is electronically swept rapidly back and forth across the strip. All portions of the surface are scanned, and defects detected produce voltage signals inversely proportional to the reflectance of the material at that point.

Any defect that is equal to or greater than the size of the elemental area being viewed will produce the same amplitude signal as any larger area of the same reflectance, regardless of the relative sizes of the two defects. This is unfortunate, for if a certain level of reflectance is adopted as a criterion—rejecting all material having spots below this level—very small spots of low reflectance will cause rejection of whole sheets of material, while large objectionable spots having slightly higher reflectance on other sheets will be accepted as being passable. When these sheets are examined, it becomes immediately apparent that the human inspector takes size, as well as reflectivity, into account in forming an opinion.

Computer circuits can be added to permit grad-

ing defects by size as well as reflectivity, and correlation with human judgment will be improved. However, spot size and reflectivity are not the only criteria employed by a human inspector. For example, color and the number of spots per square yard are also very important. Gradually, by adding complexity, it is possible to build equipment capable of judging all qualities considered by humans. When this complexity is reached, it might be expected that the task is complete, but this is not true.

An equally difficult job remains: To set into the controls of the photoelectric inspector the levels of individual and combined parameters which shall cause rejection. It is here that the designer begins to more fully appreciate the marvelous abilities with which the Creator has endowed a human inspector. For example, it has been estimated that the cost of writing complete specifications by which the tinplate is to be judged automatically is about equal to the cost of developing the device itself.

In spite of all the problems involved, it is almost certain that devices of this type will be in use in the near future. Some tinplate lines now being constructed are providing space for future addition of automatic surface inspection. The reason for this is primarily that increasing machine speed is outstripping the ability of humans to inspect or signal defects accurately.

Three areas of photoelectric inspection have been considered. These include: 1. *Go No-Go*, using simple photoelectric relays to judge a single quality. 2. More sensitive and accurate *Go No-Go*, using highly specialized equipment. 3. Judgment based on several parameters which may mutually interact.

In all of these areas the following advantages of photoelectric inspection over manual inspection are apparent: 1. Inspection may be carried out on a line at high speed. 2. The entire production is inspected; the device does not "glance away" while a flaw goes unnoticed. 3. The inspection is uniform. It does not vary from hour to hour, and agrees with results in other plants. 4. The cost is almost always lower when inspecting a single parameter.

To obtain these advantages, the problem must be carefully specified and consideration given to all parameters involved and how these parameters interact to affect over-all product quality.

Control Applications

Moving webs or strips of material must often be controlled for optimum machine performance. In many cases, photoelectric control is frequently the best and sometimes the only practical control system. Strip operations most often controlled are: 1. Depth of loops. 2. Sidewise or edge alignment of web with the machine. 3. Lengthwise synchronization of printed or punched webs with cutters or printing cylinders.

Loops are often used between separately driven sections of machines to prevent overstressing or breaking the web during transient conditions. The speed of one section is closely matched to that of the other, but supplemental control is required to maintain proper loop depth. Dancer rolls or other mechanical means may be used to sense loop position and actuate vernier speed control of one of the drives to maintain proper depth. However, where the web is fragile and subject to damage by mechanical sensors, or where the sensors are subject to damage from the strip, a nonwearing inertialess light beam can be used to provide a signal proportional to web depth for fast, accurate control.

A typical system of this type is shown in *Fig.* 5. In this setup, the output of the control is a current

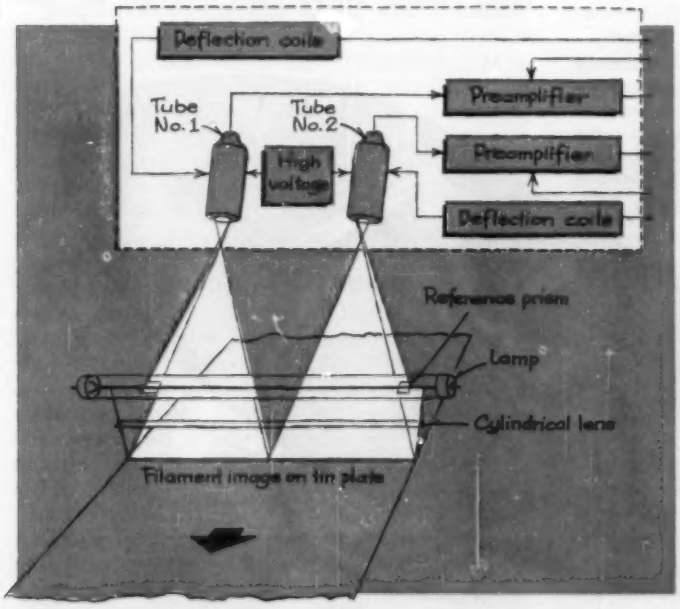


Fig. 4—Flaws in the surface of tinplated strip are detected by this photoelectric surface inspector which uses image dissector tubes to rapidly scan across the strip. A lamp projects a narrow strip of light across the strip. At the same time, each reference prism directs a beam of light from the lamp to its associated image dissector tube. As each tube rapidly scans the reflected light from the strip, flaws such as dents, oil spots, welds, or missing tinplate cause a decrease in reflected light. This reduction in light intensity is sensed by comparison with the light from the prism and causes a change in electrical output signal from the dissector tube.

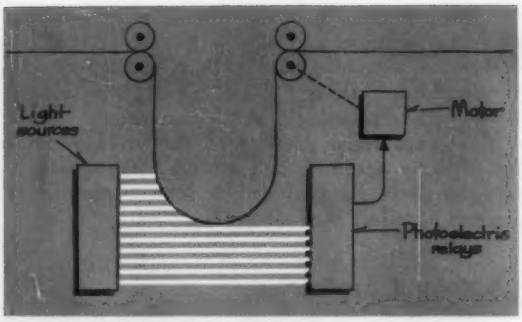


Fig. 5—Maintaining proper loop depth in a moving web is a common control application of photoelectric devices. The amount of light striking the photocells creates a proportional current which is used to increase or decrease the motor speed of the web drive. Any number of photoelectric relays may be used to sense the loop depth. Each relay inserts or removes an increment of resistance in the field or armature of the drive motor. By using a number of photocells, smaller increments of change can be made at any one time and the system will have smoother operation.

proportional to the amount of light striking the photoelectric pickup. This output is used to buck or boost the field or armature current of the pay-off or take-up drive to give the necessary vernier control. Such systems are fast and smooth. If the rate of change of loop position is slow, several standard photoelectric relays may be used by positioning their separate light beams to intersect the loop at different depths. As each beam is broken, it operates an associated relay to insert more or less field resistance in the drive motor, or acts in some equivalent way to control the drive speed. Such systems are naturally unstable and will hunt around the control point, but often this is not objectionable. They are inexpensive and may be quickly set up using standard photoelectric relays.

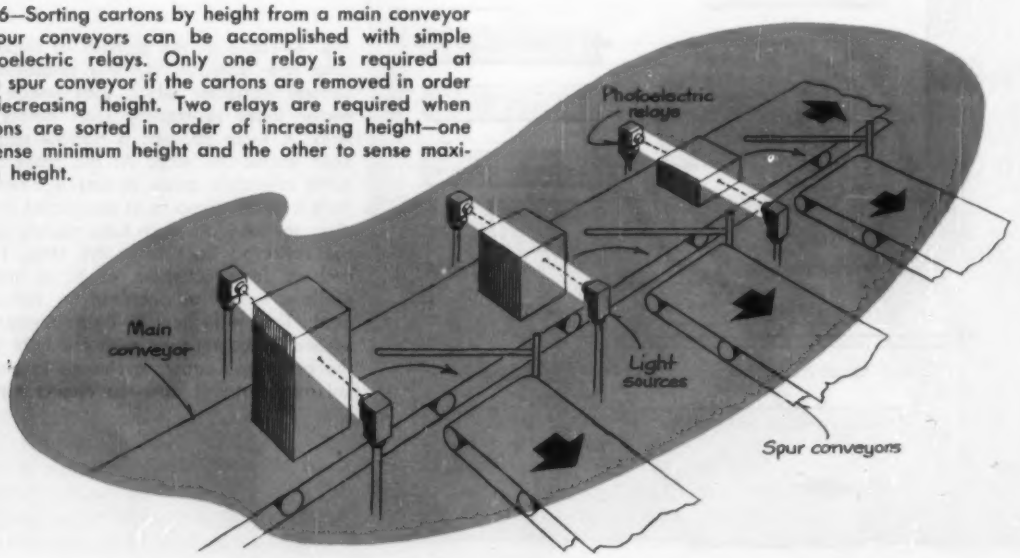
Side register control is important where slitting, trimming, printing, or blanking operations are involved. Photoelectric side register control systems may be used to sense and control the position of the edge of a web. They have the distinct advantage over other types of control systems of being able to sense printed lines or patterns and to control their positions relative to slitting or other operations. Where operations performed on a printed web are to be oriented relative to the printed pattern and not to the material edge, photoelectric control is much more accurate than other types of edge guides. This is especially true in cases where the printing was originally registered relative to an edge that varied. Any misregister in printing due to edge changes is not a factor.

A photoelectric side register control system consists of a scanner, a control panel, and a correction motor. Control panels are available for on-off control or proportional control. With high accuracy proportional systems, register may be held within a few thousandths of an inch.

Longitudinal registration control is usually required where cutting, blanking, folding, or additional printing must be done on printed webs. Mechanical sprocket feeds are sometimes used, but the majority of such applications require photoelectric control because of the necessity to sense the printed pattern directly. Also, elimination of punching the web for sprocket feed devices permits considerable increase in printing press speed.

The control system may consist of a scanner to sense pattern position; a switch or photoelectric pulse generator to sense knife, print cylinder, or blanker position; and a control panel to compare the phase of the two signals and cause operation of a correction motor when the phase relationship drifts. The web is usually fed at a correct speed to maintain proper register; the control merely makes up for minor machine slippage, web shrinkage, etc. An-

Fig. 6—Sorting cartons by height from a main conveyor to spur conveyors can be accomplished with simple photoelectric relays. Only one relay is required at each spur conveyor if the cartons are removed in order of decreasing height. Two relays are required when cartons are sorted in order of increasing height—one to sense minimum height and the other to sense maximum height.



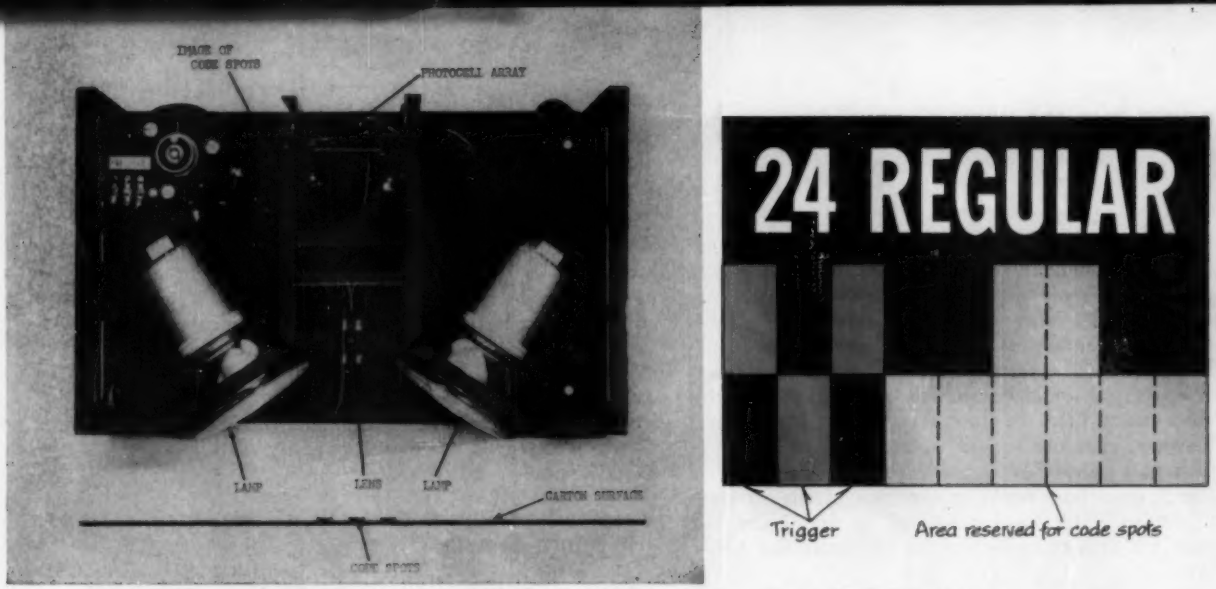


Fig. 7—A code marking such as shown in the diagram can be used when a large number of items must be sorted. The scanner illuminates the code spots so that the lens can project the pattern image onto a mosaic containing one photocell for each possible spot. Before the equipment will respond to the code, the three trigger spots must occur in a dark-light-dark relationship. If the trigger code is correct, the condition of all the photocells is sensed simultaneously. This coding is compared to a preset coding for a particular station by logic circuits, and, if correct, initiates devices to remove products from a conveyor or to perform some other control action.

other common approach is to stop the web each time a registration mark is sensed, and then perform the required operation. Such controls are almost the same as standard photoelectric relays except that certain controls are provided for the sake of convenience.

▶ Code Recognition

Most automatic conveyor control and warehousing applications require automatic product identification if more than one product is handled. Again, there are several levels of problem complexity. In order of increasing complexity, these levels are, as follows: 1. Recognition of one of a few products by product size, color, or other prominent characteristics. 2. Recognition of one of a few products by position of code marks applied to product. 3. Recognition of one of many different products by multiple code spots arranged in binary or other code.

Products having different heights may be shunted from a main conveyor to different spur conveyors by a system using simple photoelectric relays, *Fig.* 6. Only a single light beam is required at each spur conveyor if the products are removed in order of decreasing height. If any other order of removal is required, two beams for each spur conveyor are required. One is used to detect that a product has at least the minimum height, and the other to sense that the product is not higher than desired.

Sorting by *Go No-Go* physical size is much simpler than sorting by color or some other quality which involves a degree evaluation. Systems dependent upon color and other qualities which must be handled in analog form are generally limited to sorting only two or three items, if the equipment is to be kept reliable and simple. Photoelectric color sorters which can detect the difference between thousands of different shades and hues have been made for inspection purposes. However, these devices are complex and expensive and generally could not be applied economically for product identification. They are, on the other hand, quite practical when the objective is inspection plus sorting.

Often, it is not possible to sort products by size since standard size containers may be used for a number of different items. In this case, if the number of different products is relatively small, it may be possible to mark each container distinctively at some definite location and sense these marks. For example, identical cartons containing three different products could be marked with a white spot at the top, center, or bottom of a side, depending upon the contents. Sensing would be by reflected light, and the system would be closely equivalent to identification of products by box height. Marks may be spaced lengthwise along the box as well as in height to permit recognition of a greater number of items.

Often, the marking of packages in this manner is objectionable due to the lack of co-ordination with carton art work. When more than a dozen different items are to be differentiated, it is normally better to assign a small standard location on the carton for a series of spots arranged in a code. This requires use of a special purpose code reader instead of standard photoelectric relays, but in turn provides

a system which is much more flexible. One form of coding commonly used is shown in *Fig.* 7. The size of the spots depends upon the tolerances in printing and folding the carton, sharpness of printing, and accuracy of positioning of the carton to be read. Such a pattern could be put on the head of a pin and would be perfectly usable if these variables were held absolutely constant. Practically, however, spot size should be about ¼ inch by ¼ inch plus an additional vertical height (for a horizontal conveyor) equal to the sum of the various tolerances. The spots illustrated in *Fig.* 7 are ½ inch x 1 inch since there is no particular size limitation.

In operation, a scanner floodlights the code spots and projects an image of them onto a mosaic containing one photocell for each possible spot. Three of the spots, marked *Trigger* in *Fig.* 7, must occur in a dark-light-dark relationship before the equipment will respond to a code. When this occurs, the condition of all photocells is read simultaneously. Logic circuits then compare the coding with that selected by the operator and cause desired cartons to be removed from the conveyor at that point. A separate code reader is required at each take-off point.

Depending upon conveyor dimensions, number of take-off points, and number of different codes to be handled, it may sometimes be more economical to use a single centrally located code reader to read all cartons and dispatch them to the proper terminal locations by means of a shift register or other memory technique. One application has been proposed in which a single code reader would feed a computer to permit separately counting the quantities of up to 4000 differently coded products using a three-spot trigger and binary code. This requires 15 code spots. Various types of coding using magnetic pick-ups and magnetic ink, x-rays and thin metal inserts, etc. were investigated in the initial approach to this problem. A photoelectric approach was chosen because: 1. The cost per box is very low since usually one of the inks used to print the carton may also print the code. 2. No physical contact is required with the box, nor is positioning of the box extremely critical.

In surveying the field for possible code recognition applications, one may conclude that the greatest area for immediate savings with minimum capital investment is that of the simple sort-by-height or by single code spot which requires only a standard photoelectric relay. The cost of equipment and installation is low, the returns are immediate, and the possible applications are many. The multispot code readers should become increasingly useful tools for automation of large systems, and are necessary in smaller systems where the quantity of different items is large.

Future Growth

It has not been possible, within the scope of this discussion, to do more than touch briefly on the more common present-day applications of photoelectric control. A look to the future would show that great growth is still to come in this area. Every physics textbook is filled with optical principles which are still to be widely applied to photoelectric control. Most common controls in use today depend upon simple reflection or transmission of light.

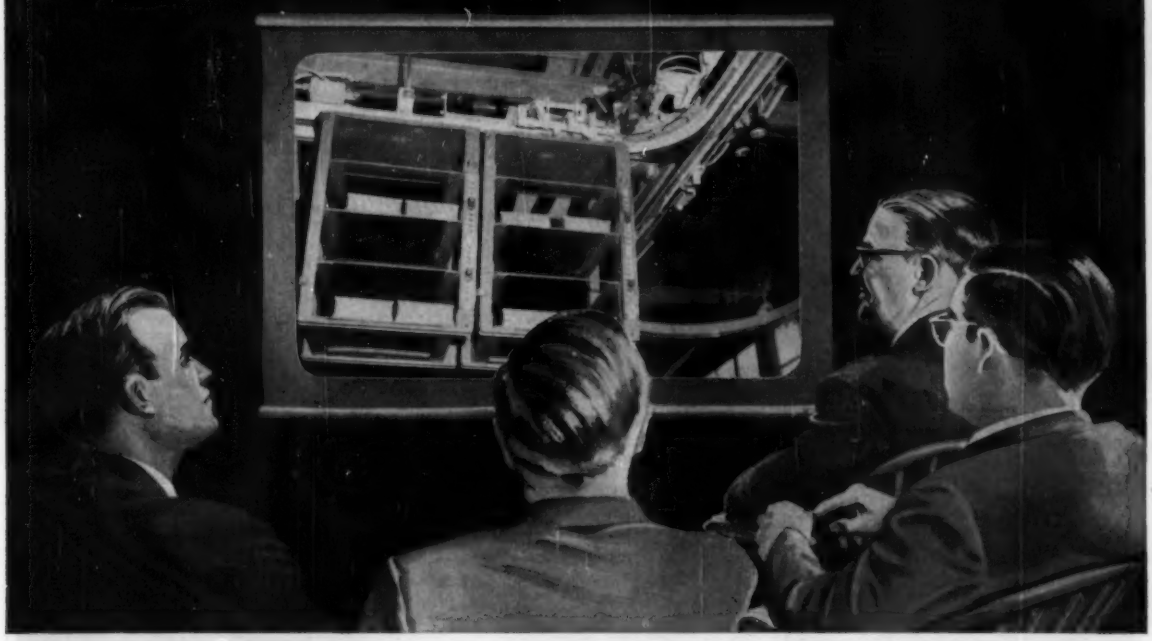
One byproduct of our expanded defense effort is the development of improved photoelectric components which appear almost daily on the market. For example, solar cells for powering satellite transmitters are also useful in many industrial applications. The combination of these new components with more sophisticated optical systems, together with the growing need for all types of data handling and processing equipment, assures continued rapid growth.

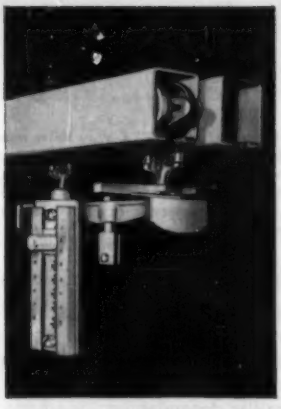
One cannot know just what new devices and systems lie ahead. Generally, however, we may predict that photoelectric systems will approach much more closely the abilities of the human eye in such areas as pattern recognition and inspection where some degree of logic is required. The extent to which this can be accomplished at reasonable cost will determine the pace of automation in the many places where human beings are employed as sensors to feed data to otherwise automatic systems.

can we help?

It has been pointedly mentioned at various times that in engineering automated systems new as well as old techniques and devices may prove extremely useful. Practical results require the investigation of all available equipment that can contribute to the effective development of suitable automatic lines. Information on such equipment is presented in various departments of the magazine each month as useful data become available. To aid in obtaining detailed data for further evaluation a post card is included on page 19. Take advantage of this service. The Editors will be glad to help in this or any other way.

See the cost-saving advantages of an R-W "TWIN-TRAK" OVERHEAD AUTOMATIC DISPATCH SYSTEM demonstrated in your office!





An R-W "TWIN-TRAK" Overhead Automatic Dispatch System consists of one or more Power Track and as many Storage or Load Tracks as desired plus Switches, Carriers, Accessories and Power Equipment. "TWIN-TRAK" Systems are economical to install and maintain . . . easy to expand, alter or relocate as necessary.

The handling ot materials offers American industry its greatest cost-cutting frontier and reduced costs will be accomplished only with a "true" integrated materials handling system that coordinates all production functions on a plant wide basis. A new movie has just been produced that graphically demonstrates how R-W "TWIN-TRAK" Automatic Dispatch Systems meet this need. "TWIN-TRAK" is a completely automatic conveying system that selectively conveys parts, components and products throughout all production processes. Parts and components may be inventoried in overhead storage banks and then automatically selected and transported *where* they are needed—*when* they are needed. Write today to arrange for a showing of this film in your office.

Richards-Wilcox

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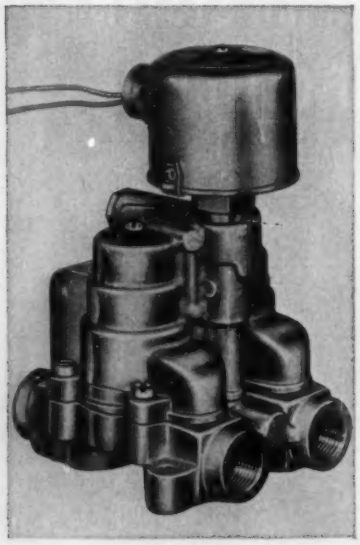
Circle 680 on Page 19

(Advertisement)

Why Name an Air Valve "Mach 2"?

"Mach 2" is the name of a new Crescent® Air Valve now ready for distribution to industry. An identifying name is desirable for this valve to point up the new kind of performance it brings to air control and to distinguish it from the other valves in the long-established Crescent® line.



The new Crescent "Mach 2" 4-Way Valve. (Half-inch pipe size shown.)

A Breakthrough in Cycling Speed

Actually these Crescent® "Mach 2" 3-Way and 4-Way Air Valves represent a breakthrough, as the name suggests. For years a cycling speed of 600 to 700 cycles a minute seemed to be the limit for solenoid pilot valves. The original Crescent 4-Way Valves attained that speed a long time before other valves even approached it. Now, the "Mach 2" has been tested and rated for 1000 cycles per minute continuous duty. During a two-hour test at a speed of over 1500 cycles per minute the coil temperature stabilized at 7°C below the maximum code limit for class A coils. Cycling speeds as high as 2100 have been successfully reached for intermittent periods of 20 minutes.

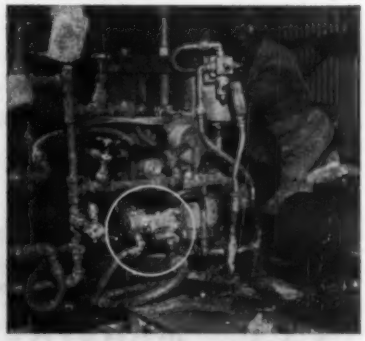
Brings New Dependability

We realize that such high cycling speeds are seldom needed. However, speed and endurance seem to be Siamese twins. Here's why: (1) Speed depends on an extremely short stroke of the solenoid plunger (3/32 of an inch—approximately the thickness of a nickel—in the new "Mach 2"). This greatly reduces coil heating and, as heat goes down, coil life expectancy goes up. (2) High cycling speeds demand a drastic reduction of friction in the solenoid and pilot valve section. In the "Mach 2" pilot valve, a tiny ball seats on "O" rings at both ends of a pilot cartridge. The ball moves freely, independent of the seals. There is no "O" ring drag on the pilot plunger because it requires no seals; where there is no friction there can be no wear.

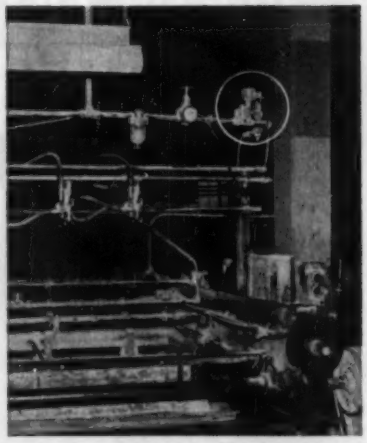
Similarly, the main valve seats seal on "O" rings. Metal shoulders take the shock in such a way that the "O" ring seal is merely kissed by the seat in the sealed position; since they are only minutely flexed they don't fatigue or lose their resilience.

100 Million Cycle Guarantee

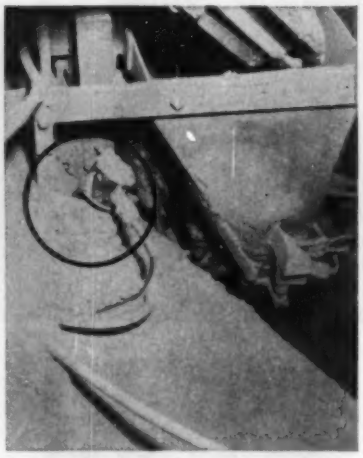
Because of the short solenoid plunger stroke and the elimination of friction, there seems to be no limit to the endurance of the solenoid coils in "Mach 2" Valves. We back up this statement by guaranteeing the coil life for a minimum of 100 million cycles. For six years "Mach 2" Valves have undergone test. Valves have been placed in some of the toughest applications we could find to test their performance capabilities in actual service before introducing them to the market. Some were installed in plants where they were subjected to very fast-cycling, continuous operation. Others have been operating where they are exposed to excessive dirt, dust and dampness, and in all cases the "Mach 2" Valves are performing flawlessly. In fact, some operators balked at having us remove them for inspection. To test the new waterproofing treatment of the "Mach 2" coils, one of the units was completely submerged in a container of water on April 26, 1959, and it is still functioning perfectly.



Crescent "Mach 2" 4-Way Valve on a roofing paper machine. This machine operates 24 hours per day, 7 days per week.



Large printing press used to imprint cardboard cartons. "Mach 2" 3-Way Valve controls spray nozzles which apply "offset spray." Production speed of this machine is 2000 cycles per hour.



This Crescent "Mach 2" 4-Way Valve operates the hopper doors at a cement batching plant. The valve has been operating at 1400 cycles per day surrounded by dry cement. We actually had to dig the cement away from the valve to get a picture.

Write for the "Mach 2" Catalog

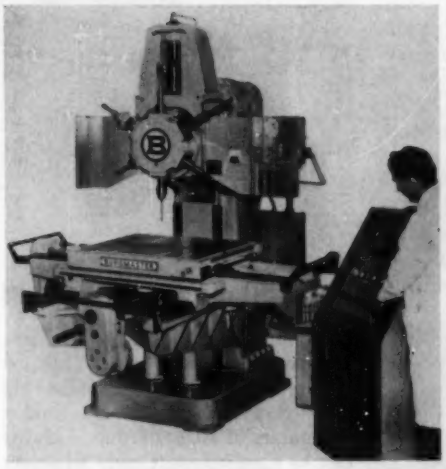
Crescent® "Mach 2" Solenoid Pilot Operated Air Valves represent a significant breakthrough in "the cycling speed barrier" and in valve life and operating dependability. We hope you will approve of the unusual name, "Mach 2." We know you will approve of the low-cost, downtime-free performance the "Mach 2" will deliver on your tough jobs. Please write to Barksdale Valves, 5125 Alcoa Avenue, Los Angeles 58, California, and request an advance copy of the "Mach 2" catalog.

Circle 681 on Page 19

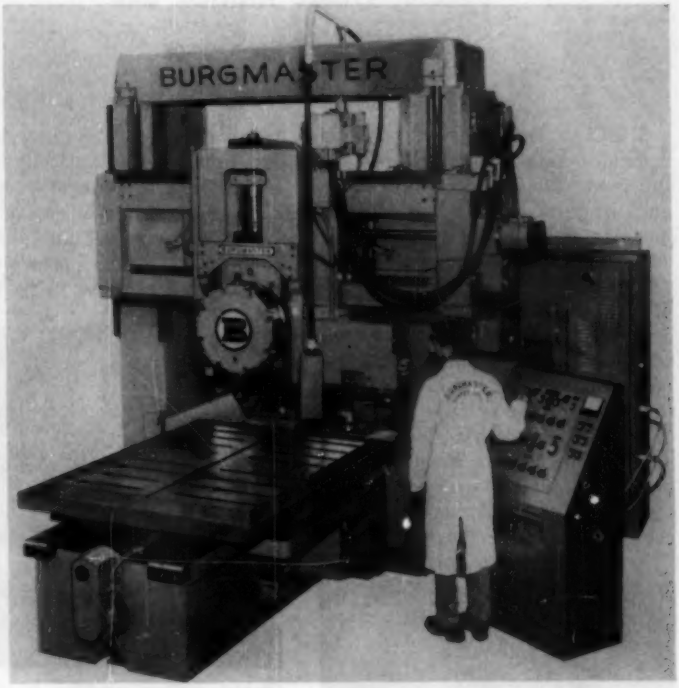
AUTOMATION

new equipment

Machines and plant equipment for more automatic operations.
For detailed information and literature, use card Page 19.



Model 25AHT has a V-type cam lock clamping ring which gives maximum rigidity to the turret during heavy machining cuts. One-piece forged spindles with integral gears, double row bearings at spindle nose, and single row bearings at rear increase strength and operating precision.



Both the table and turret carriage of Model 3BHT-B are rigidly clamped in any position with air clamps and lead screw brakes. Friction and wear of the table bed ways is minimized through the use of hardened ways, recirculating roller bearing cartridges, and spring steel dust covers to prevent contamination of the ways or bearings.

Tape Controlled Turret Drills

TWO new additions have been made to the line of automatic hydraulic turret drills developed by **Burg Tool Mfg. Co.**, Gardena, Calif., and designed for such operations as drilling, reaming, tapping, boring, counterboring, spotfacing, and porting. The turret on each machine is designed to bring several spindles and a variety of tools to the work, thus speeding up multiple machining operations, reducing work handling, and also reducing the amount of floor space required. The turret is hydraulically fed to the work at a feed rate preselected on standard machine controls. Each machine utilizes a positioning table to locate the work under the turret. They perform all machining operations in a setup automatically, and will machine complex hole patterns with speed and accuracy. Hole center distances are held within ±0.001 inch. Programming of the drills requires an average of one minute per hole location, and preparation of tape averages 4 holes per minute. Setup for the machines is from 3 to 5 minutes per tool.

Model 25AHT has a 6-spindle turret. With a 1¼-inch drill and tap capacity in steel, it is a heavy duty unit weighing up to 10,000 lb. It is offered with table sizes 15 by 26 or 20 by 30. Preselective infinitely variable hydraulic feeds from ½ to 50 inches per minute are constant and positive, with temperature and pressure compensation. Feeds are dial-set from a direct reading meter. Standard controls provide 12 speeds in 3 ranges of 4 speeds per spindle from 115 to 1975 rpm. Optional 4-speed motor doubles the number of speeds with 24 speeds in 3 ranges of 8

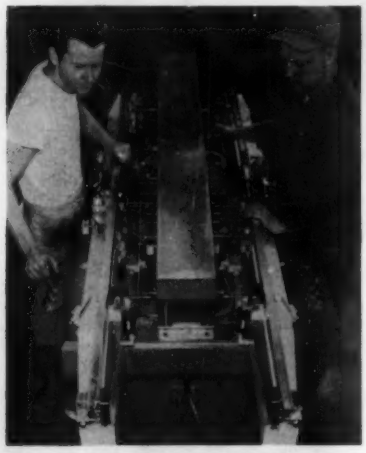
speeds per spindle from 90 to 3000 rpm.

Model 3BHT-B is a double housing planer type machine with an 8-spindle turret having a 1½-inch capacity. By employing a bridge to support a laterally traversing turret carriage, the machine provides X-Y table positioning capacity of 40 by 60 inches and a vertical clearance of the spindle nose over the table of 39 inches with the bridge up. The turret feeds 12 inches independent of the bridge at any point from 39 to 3 inches from the table top. A 4-speed motor provides a speed range of 24 speeds in 3 ranges of 8 speeds per spindle. Lead screws and roller bearings on the table work in a recirculating filtered oil bath.

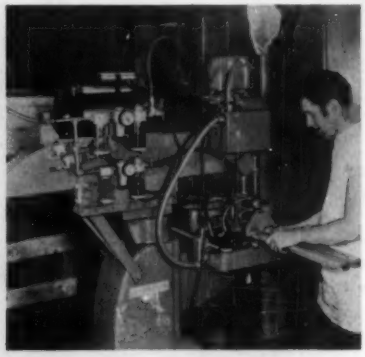
Circle 401 on Page 19

Special Frame Milling and Drilling Machines

SPECIAL milling and drilling machines have been developed for the production of aluminum doors and windows. The special milling machine mills ends of the extruded aluminum cross members to fit the decorative shape of perpendicular side rails before they are drilled. A 1-hp 2-speed motor, which rotates a milling cutter six inches in diameter at 7200 rpm, is connected to the spindle by means of a timing belt drive. The ram is actuated by means of a hydraulically checked air cylinder, and a special milling fixture with air clamps is bolted to the table. Four-way valves on the ram and fixture are interlocked electrically to give a completely automatic cycle of clamps, feed, retract and unclamp. No cycle can begin until the extrusions are properly positioned for milling. Complete cycle time of the unit is two seconds.



Twenty-six spindle special drilling machine has two completely independent work stations. Each allows three different multiple drilling operations on matching extruded and cast aluminum components. The machine's air operated clamps and cycling cylinders will not operate unless the drill motors have been turned on; thus drill breakage is reduced.



Special milling machine is ruggedly constructed to mill the ends of extruded aluminum cross members to exactly fit the decorative shape of perpendicular side rails before they are drilled. A special milling fixture with air clamps is bolted to the table, and four-way valves on the ram and fixture are interlocked electrically to give a completely automatic cycle of clamp, feed, retract, and unclamp.

The special drilling machine has two completely independent work stations, each allowing three different multiple drilling operations on matching extruded and cast aluminum components. The machine is capable of drilling 26 aligned and matched holes in less than 15 seconds. The drill pattern is such that once positioned, none of the drills have to be changed or removed when different parts are to be drilled. The drilling machine is shown as door side rails are being drilled. After a rail is positioned in a fixture, three air clamps lock it in place. The machine then goes through an automatic cycle of rapid advance, feed, rapid return and unclamp. I. O. Johansson Co., Skokie,Ill.

Circle 402 on Page 19

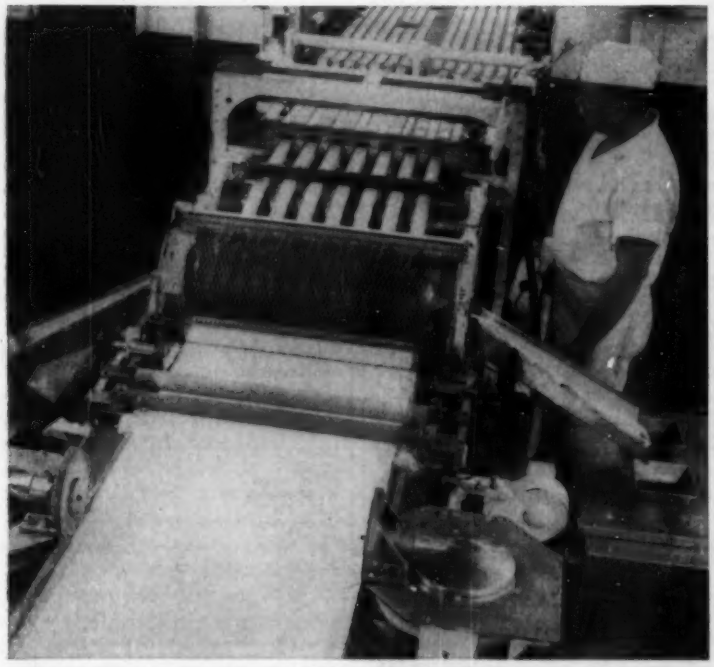
Recording Control System

Digital recording and control system with a capacity of 100,000 channels is designed for monitoring and controlling up to 10 analog computers of 10,000 inputs each. It can be used independently wherever data logging, reduction, and control are required, such as in process operations. When used in analog computing facility, it will speed up or eliminate problem setup and checkout tasks. By the use of punched tape, it can select a computer, place it into any one of its operating modes, set the computing elements such as potentiometers, with an accuracy of ±0.01 per cent, read back the voltage variables to check settings of computing elements, and then initiate problem solution. This system can also verify the selection circuitry involved in performing its function and/or compare any selected voltage with a digital reference value to within an adjustable tolerance as small as 0.01 volt. It can also automatically repeat problem runs with new voltage variable settings and/or addresses in any selected computer to obtain solutions for wide ranges of parameter values. Each channel is identified by a four-character address and may carry any voltage in the ±100v range. Complete circuitry for tape preparation, checking, and editing is included in the system. The tape

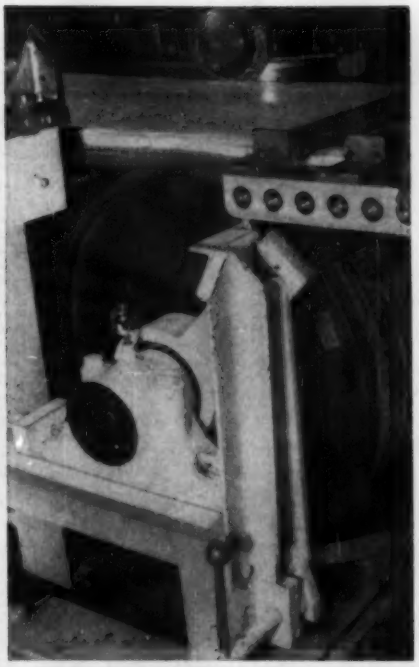
Mars, Inc.
maintains product uniformity

with USS **Lorig-Aligner** Self-Centering Rolls

This mark tells you a product is made of modern, dependable Steel.



Cooled slab of nougat rides the Stainless Steel belt to the cutting machinery where it is slit to candy-bar width and cross-cut to length.



MARS uses USS LORIG-ALIGNER Type III Rolls to center Stainless Steel belt carrying candy slab.

Mars, Inc. produces millions of candy bars a day and USS LORIG-ALIGNER Self-Centering Rolls help maintain uniformity from bar to bar.

At Mars, a steady stream of warm candy pours from the mixers onto a 32" wide x 150' long Stainless Steel belt moving at high speed. At this point, the candy is formed into a continuous slab of nougat that has been accurately sized to a width and thickness. Solidification then takes place as the slab is carried through a refrigerated muffle. As it leaves the delivery end of the muffle and is discharged from the belt, the slab of nougat is slit to candy-bar width and cross-cut to length.

Hour after hour this operation continues, with little variance in size. The answer to such uniform and unerring tracking lies in the USS LORIG-ALIGNER Self-Centering Rolls which carry the belt.

The self-centering action inherent in LORIG-ALIGNER Self-Centering Rolls compels the belt to travel in *exactly* the same path each revolution. Therefore, the slab of candy has no lateral movement because the belt's roll-established center-line does not weave, even though the cambered edges of the belt may show a variation in travel. Such accurate control of belt travel assures increased production and yield, and lowers maintenance costs.

USS LORIG-ALIGNER Self-Centering Rolls eliminate the need for expensive roll-tilting mechanisms and complicated edge-travel sensing devices. There is no belt distortion with LORIG-ALIGNER Rolls because high belt tension is not necessary. USS LORIG-ALIGNER Self-Centering Rolls have many applications, and we will be glad to tell you about them. Just mail the coupon for more information.

USS and "LORIG-ALIGNER" are registered trademarks of United States Steel
"MARS" is a registered trademark of Mars, Inc., Chicago, Ill.

United States Steel
Room 2801, 525 William Penn Place
Pittsburgh 30, Pa.

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American Steel & Wire — Cleveland
National Tube — Pittsburgh
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Tennessee Coal & Iron — Fairfield, Alabama
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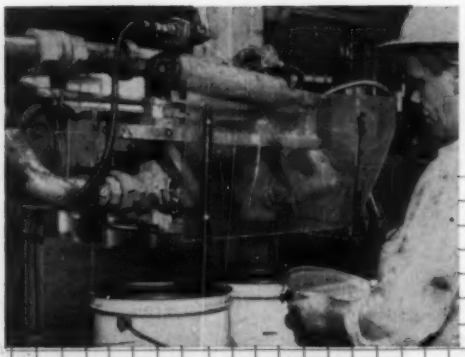
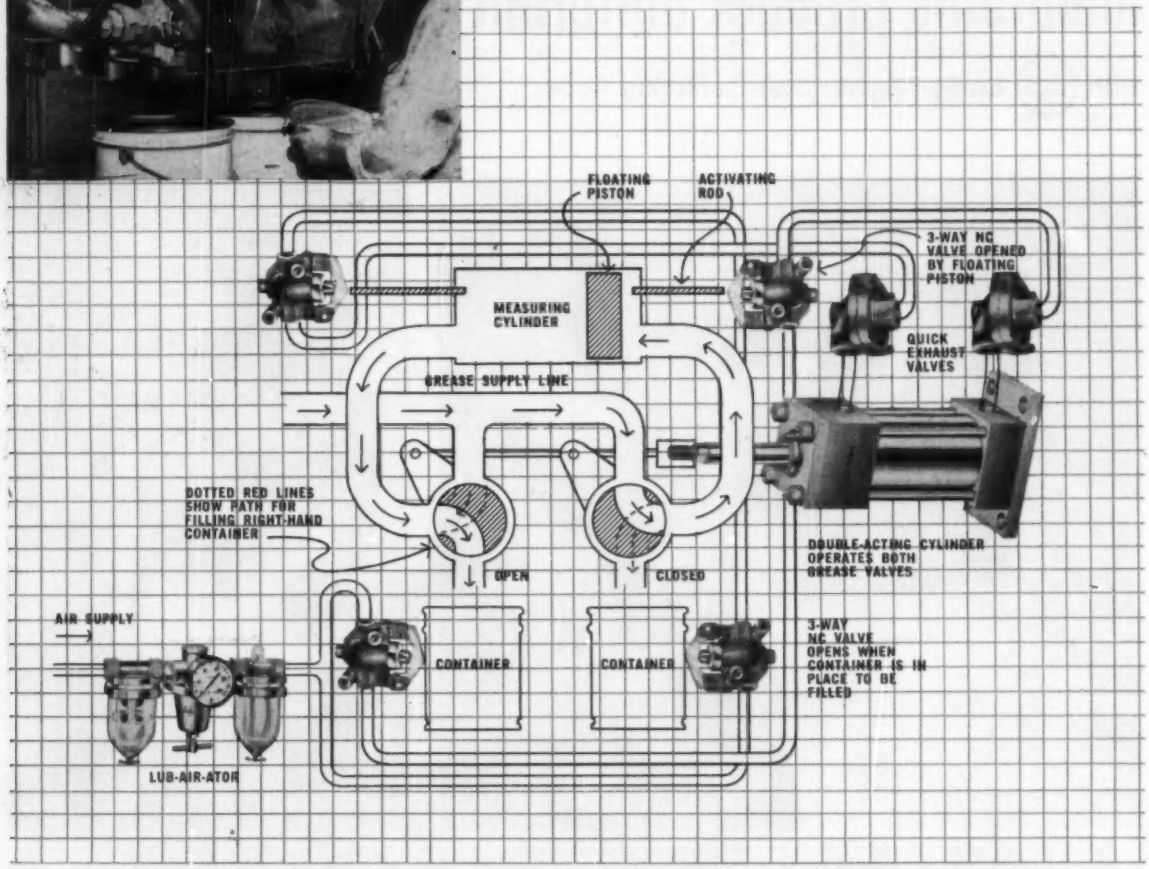
United States Steel



Here is an example of Schrader at work. Barrett Mfg. Co. of Houston, Texas, makes grease handling equipment for Mobil Oil's Brooklyn, N. Y., refinery. This machine fills 35 pound grease drums automatically accurately, 15 per minute! George Barrett, who designed and built this machine and other machines for Mobil, says: "My reputation for quality is too hard-won to risk by using some inferior line of air products."



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punch is controlled by signals from an electric typewriter or digital voltmeter output. **Computer Systems Inc.**, Culver Rd., Monmouth Junction, N. J.

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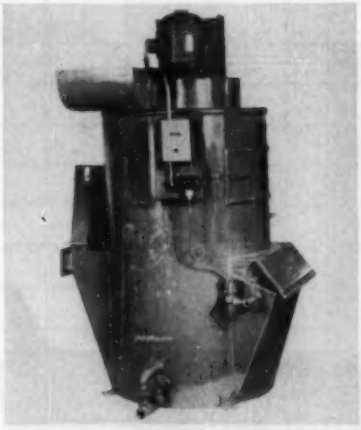

Dust Collectors

Complete and compact units are particularly adaptable to metal grinding and finishing operations. They will remove dirt, dust, grindings, chips, fumes, and vapors. No pumps or agitators are used in the air-washing process. These wet type dust collectors, designated Uni-Wash, have no moving parts and require minimum floor space. Several models are available. Custom units for unusual requirements can be obtained. **DeVilbiss Co.**, Toledo, Ohio.

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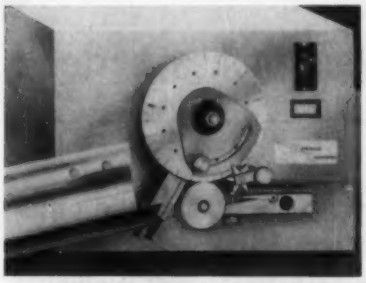

Wire Cutter

Unit is designed specifically for production applications in the electronics and electromechanical assembly fields. Operating on normal 115 volts/60 cycle power, this wire cutter can be set up and running in a matter of a few minutes on any convenient bench or table. Wire lengths from 1 to 60 inches can be produced in production quantities. A special attachment is available for jobs requiring lengths to 240 inches. All types of bare and insulated wire can be handled without marring or damage. Wire sizes from 26 to 12 gage can be accommodated. All necessary adjustments for length and wire size are accomplished on the front panel and can be made in three to five minutes. An automatic throw-out permits single piece operation for prototype or set-up purposes. Typical production rates for Model CWA-300 are 3600 pieces per hour for a length of 20 inches and 900 pieces per hour for a length of 60 inches. A reset counter is provided on the front panel, and a preset counter switch is available as optional equipment. **Dickinson & Associates**, 940 Alma St., Glendale 2, Calif.

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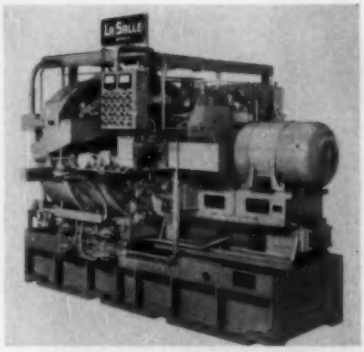

Trunnion Machine

Six-station trunnion type machine, designated Pistonette, is designed to handle pistons for V-12 and V-6 engines. It processes three different pistons used for trucks, busses, tractors, heavy-duty equipment, heavy-power equipment, or marine engines. Feature of the unit is its compactness; it requires only 108 square feet of floor space, with over-all dimensions of 12 by 9 by 6 feet. It center drills the dome end of the piston; drills, chamfers and reams two process holes in the weight boss; and faces the weight boss for locating purposes. At 100 per cent efficiency, this unit will machine 514 pistons per hour. Its hydraulic and electrical equipment is built to JIC standards and arranged for 60 cycle, 3 phase, 220/440 volt ac. The electrical equipment, which includes an electrical control panel and pushbutton assembly, incorporates 3 basic motors. **LaSalle Machine Tool Inc.**, 3840 E. Outer Drive, Detroit 34, Mich.

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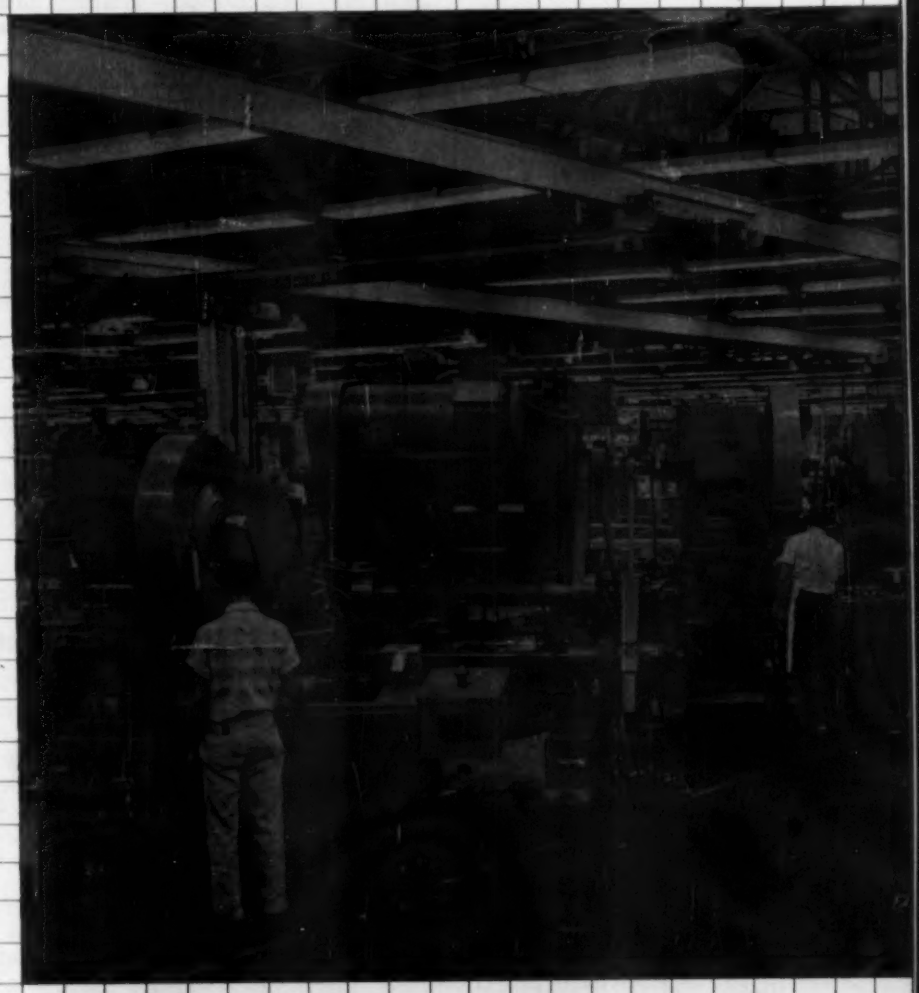
Photoelectric Scanner

Electronic inspection system automatically detects and separates imperfect items from production conveyor lines. System can detect imperfections that create as small as 3 per cent variation in light reflected or transmitted from the items being inspected. Usable with conveyor belts up to 10 ft wide and at speeds up to 600 fpm, it is adaptable to a variety of processes and production lines in the plastics, metals, glass, food processing, and textile fields. Typical applications include detecting flaws in sheet metals and sheet plastics, detecting and removing discolored food products from processing lines, and marking stains and faulty weaving in textile products. Inspector operates by detecting differences in light intensity between the flaw and its surrounding area. The system consists of an illumination source over the conveyor, and optical scanner, a data processor, a control panel, and a power supply. The actuating device for removing or marking the flaw is specially designed for each application. The scanner scans across the belt 14,000 times a minute. Light intensity signals are then fed into the data proc-

This new Westinghouse BF relay . . .

saves inches here . . .

This new Westinghouse BF relay is small and can be butted one against the other so that your control panels can be reduced in size as much as 50%. Result: valuable plant floor space available for additional machines. Because the relay is specifically designed for automated machine tools, you cut installed costs more than 20%. And since this relay is in stock, you get these savings NOW.



feet here . . .

Want more information on the 6-amp, 300-volt BF and its companion, the 10-amp, 600-volt AF? Contact your nearest Westinghouse representative . . . or write Westinghouse Electric Corporation, Standard Control Division, Beaver, Pa. J-80321-R

You can be sure...if it's **Westinghouse**

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essor which converts, at high speed, the light variations to digital form. These signals energize the specially designed actuating device which removes the imperfect item or marks the flaw. **Atronic Products Inc.**, One Bala Ave., Bala-Cynwyd, Pa.

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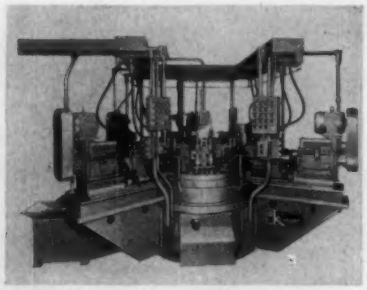

Radial Index Machine

Six-station horizontal radial index machine performs 16 operations on aluminum automotive pistons during a 13 second cycle. Handling two pistons simultaneously this machine drills, mills, chamfers, and slit-saws in one continuous operation. It features a 40-inch indexing table, and is equipped with one flat saddle type, and four self-contained quill type hydraulic units. Table indexing time is 1.5 seconds, and fixture clamping and unclamping is completely automatic. A number of different size pistons can be accommodated. **H. R. Krueger & Co.**, 1469 E. Grand Blvd., Detroit 11, Mich.

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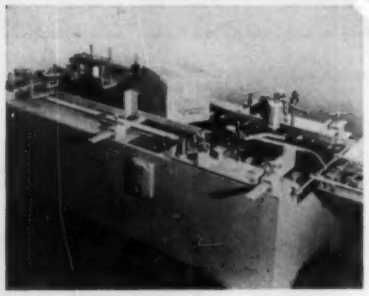

Four-Way Printer

Unit has been developed for quality in-plant carton printing. It imprints product and/or code copy from 1 by 1 inch to 10 by 20 inches on all 4 surfaces of set-up cartons, in just one pass, at a belt speed of approximately 35 cartons per minute. The conveyor unit of the press is the proper height to tie in directly with existing equipment, and the extra heavy duty conveyor handles continuous loads of 2400-2600 lb. This four-way printer can follow a case sealer of every manufacture, power unit, or gravity conveyor. Guide rails and a turning device are designed to accommodate a full range of carton sales in corrugated board of all standard weights. Printing can precede sealing operations where top and bottom flaps are not sealed. The printer contains a full day's run of ink, sufficient for up to 10,000 cartons. Inking is by capillary action, and new formula liquid inks have been developed in all colors which dry instantly for sharp, clear impressions on all surfaces. All rubber marking dies are planned for the type and test of cartons used. **Algene Marking Equipment Co.**, 232 Palisade Ave., Garfield, N. J.

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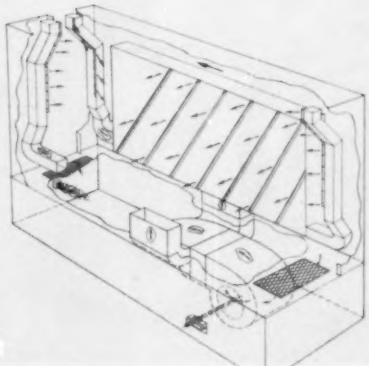

Dry-Off Ovens

Range of 24 standardized, dry-off ovens and patch-type drying units for work moving on a monorail have been designed to integrate a complete line of power spray washing, phosphatizing, painting, and other types of finishing equipment. The blower and heating units are located in the bottom of the oven. High pressure steam and gas-fired heaters are available in all models. Ovens are constructed of interlocking panels, with two inches of glass wool insulation between the inner and outer 20-gauge steel panels. Mechanical heat seals confine the heated air in the oven, where it is recirculated at a high velocity by heavy duty centrifugal fans through slots surrounding the exit and entrance. Free draining parts can be dried in under three minutes. **Ramco Equipment Corp., Div., Randall Mfg. Co. Inc.**, 1379 Lafayette Ave., New York 59, N. Y.

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Vertical Honer

Machine is capable of honing bores up to 10 inches in diameter at maximum stroke, and it will hone larger diameter bores in shorter lengths. It is available with 25, 35, 45, or 60 inches spindle travel. All electric controls are built into the two side panels of the machine. To change spindle speeds of Model 3010, the operator simply turns the two knobs on the right side of the head. One knob selects neutral, low, or high speed ranges, and the other knob selects the specific speed in either the low or high-speed range. Eight speeds are provided by a 10 hp motor with a V-belt drive. Stroke length is controlled by a dial mounted on the rear of the control panel arm. An electric hone expansion mechanism and bore sizing mechanism maintains size consistency within tenths of thousandths from bore to bore at high production rates. When limitation of stone wear is reached, lights on the control panel warn the operator, and interlocking controls prevent the start of a new honing cycle until new stones have been

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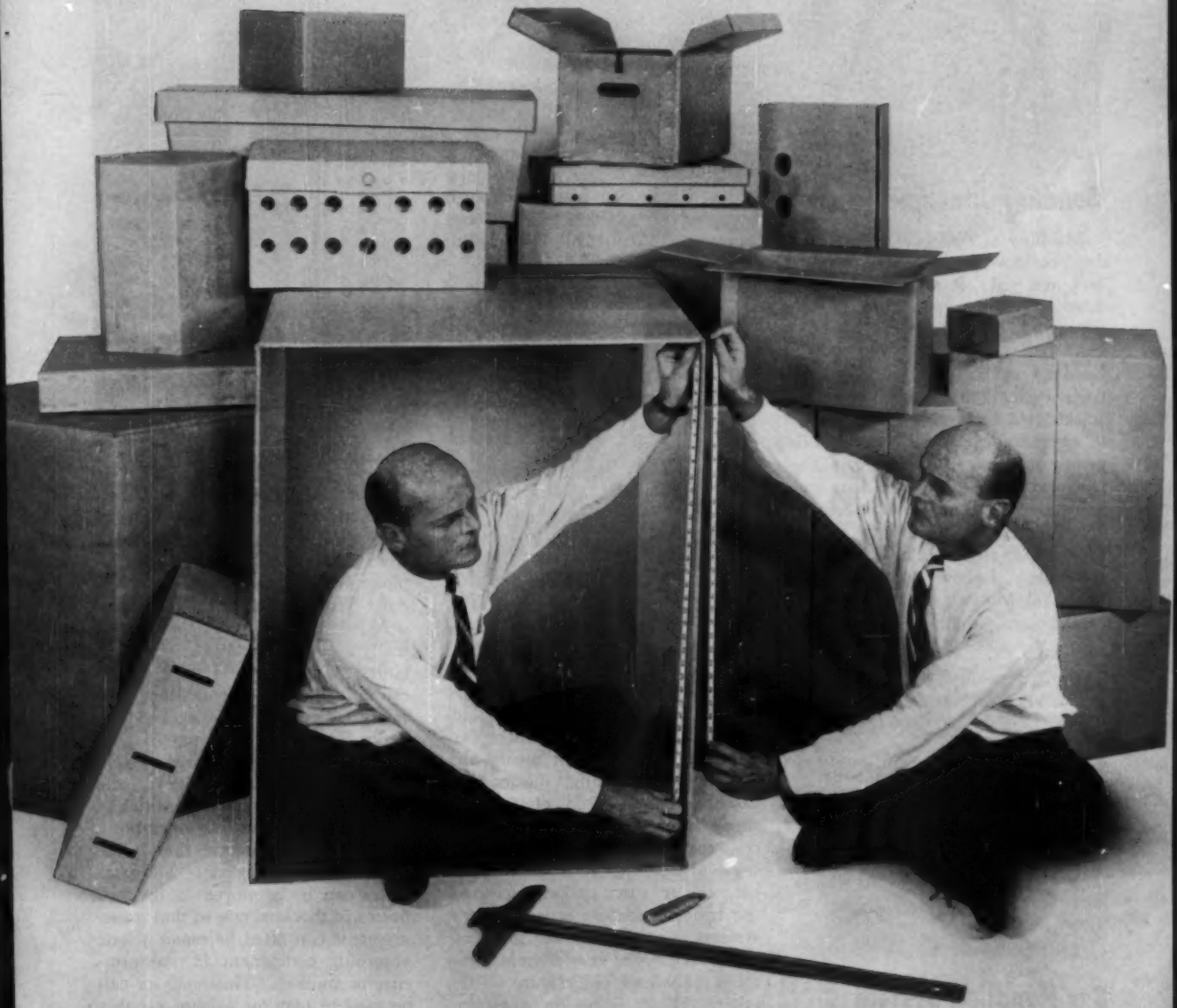
GAYLORD SOLVES
PACKAGING PROBLEMS INSIDE AND OUT

Your Gaylord Man isn't twins, he just works like it. He knows the "inside" of container manufacture and the "outside" of packaging operations, so he can give you double-duty service.

Got a packaging problem or two? Call the man who solves them by the pair—your nearby Gaylord Man. Today.



CROWN ZELLERBACH CORPORATION
GAYLORD CONTAINER DIVISION

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HEADQUARTERS, ST. LOUIS
PLANTS COAST TO COAST

inserted. A separate 10 hp motor powers the hydraulic reciprocation. The machine can short stroke at any point in the bore, and it is available with a dwell mechanism. **Barnes Drill Co.**, 836 Chestnut St., Rockford, Ill.

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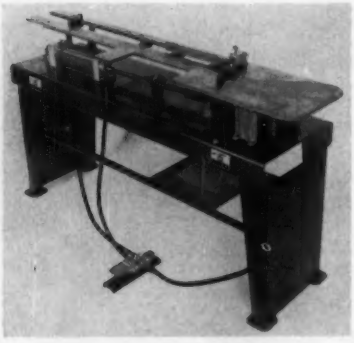

Bending Machine

Machine is designed particularly for precision angle bends of wire, bar, and rod. It will form angles, triangles, U's, squares, rectangles, pentagons, hexagons, etc. The machine is capable of averaging 500 bending cycles per hour. With each cycle, the material can be stacked 1½ inches high. Pneumatic operation is possible at 80 lb pressure or more. Capacity of the machine is up to ½-inch bar, and adjustable angle of bend is zero to 135 degrees. A turret attachment to change angle automatically is available. **Lubow Machine Co., Inc.**, 262 Mott St., New York 12, N. Y.

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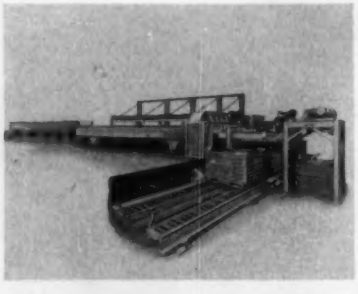

Bar Handling System

Material handling arrangement for a bar shear includes automatic bar feeding, automatic bar take-away container loading, and automatic container handling. The feeding system consists of a hopper type live roll conveyor designed to receive bundles of bars or tubes from an outdoor overhead crane and an intermediate live roll conveyor to bring the bundles indoors to an unscrambler, which unscrambles the bundles and conveys individual bars transversely onto a live V-roll conveyor to the shear. The takeaway system consists of a takeaway conveyor which takes the cut bars away from the shear and loads them into a container. When the container is full it is pushed forward onto a floor type storage conveyor, ready for transport to the process or to the storage area. The entire operation is interlocked both mechanically and electrically to synchronize all components and to operate the shear continuously at its maximum capacity. The takeaway system can handle relatively long bars in addition to short ones. **Spurgeon Co.**, 1330 Hilton Rd., Ferndale 20, Mich.

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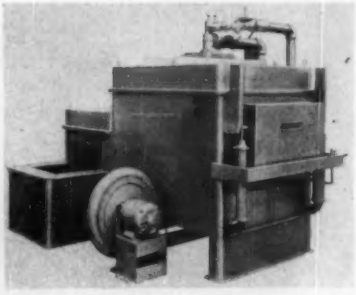

Dry Hearth Furnace

Line of double chamber dry hearth aluminum melting and holding furnaces consists of three furnace types designed for use in aluminum sand casting, die casting, and permanent mold plants. All three furnaces are of single unit construction with individual melting and holding chambers. Either gas, oil or combination fuel-fired, the furnaces feature separate firing systems in each chamber to assure rapid melting in one chamber and correct holding temperature in the other. Direct firing on a sloping dry hearth in these furnaces makes possible fast melting and immediate run-off of molten metal into the holding bath. Better metal quality is achieved as moisture is driven off before the aluminum reaches the holding chamber. Oxides and other foreign materials present in gates, risers, and scrap are deposited on the hearth during melting and can be removed with an occasional raking. Firebrick or silicon carbide linings are used. These furnaces are capable of melting from 250 to 2000 lbs of aluminum per hour with holding capacities to 2000 lbs. **Hevi-Duty Electric Co., Div., Basic Products Corp.**, Milwaukee 1, Wis.

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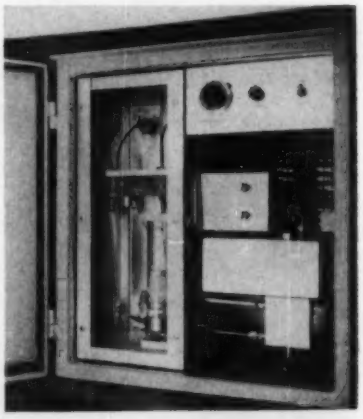
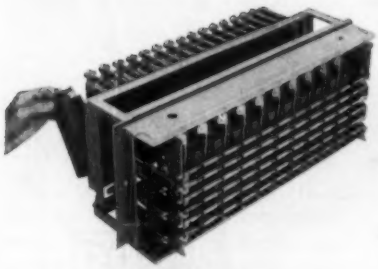
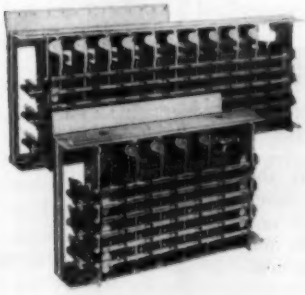


Photometric Analyzers

Line of photometric analyzers provides simple reliable analysis of absorption in the wavelength region from 2100 angstrom in the ultraviolet out to 3 microns in the infrared. They can be used to monitor or control absorbing components in many complex process streams either gas or liquid. Use of a variety of light sources and filters permit great flexibility in application. Series 500 photometric analyzer operates in the near infrared region. It is especially applicable to the measurement of small quantities of water in various hydrocarbons. Series 600 operates in the visible and ultraviolet regions. Different filters can be employed in the two beams in this analyzer so that measurements can often be made of one absorbing component in the presence of another. This analyzer can be used to monitor a large number of materials. Among those of wide interest recently have been the monitoring of butadiene and iso-

"VARIATIONS ON A THEME"





The talented conductor must know the score and interpret it brilliantly, calling upon the instruments at his command to produce the exact shadings and tonal values to enhance the inherent beauty of the composition.

So, too, must the talented design engineer have the "feel" and talent to utilize the "instruments" at his command to bring a system concept to new heights of performance and efficiency.

The design engineer's talent is dependent upon the scope and range he is permitted by the components he may utilize.

Here are three "instruments" to broaden his interpretations—to give him added range and scope—to allow him full freedom for his talent.

The standard North Crossbar switch, with 1200 switching points in a 10x12x10 matrix, allows maximum switching capacity within minimal space.

The new 5x12x10 switch gives him a new "instrument", with all the reliability and versatility of its big brother, for application where capacity requirements can be satisfied with 600 switching points!

The factory-wired Crossbar switch with North Multi-Purpose, Multi-Terminal Connectors allows new range and economy.

These three instruments will give **you** wider latitude in your interpretation of design problems—with proven reliability, versatility and economy.

For full details on North Crossbar switches, write

ELECTRONETICS DIVISION

NORTH ELECTRIC COMPANY

6212 South Market St., Galion, Ohio

60-C-8

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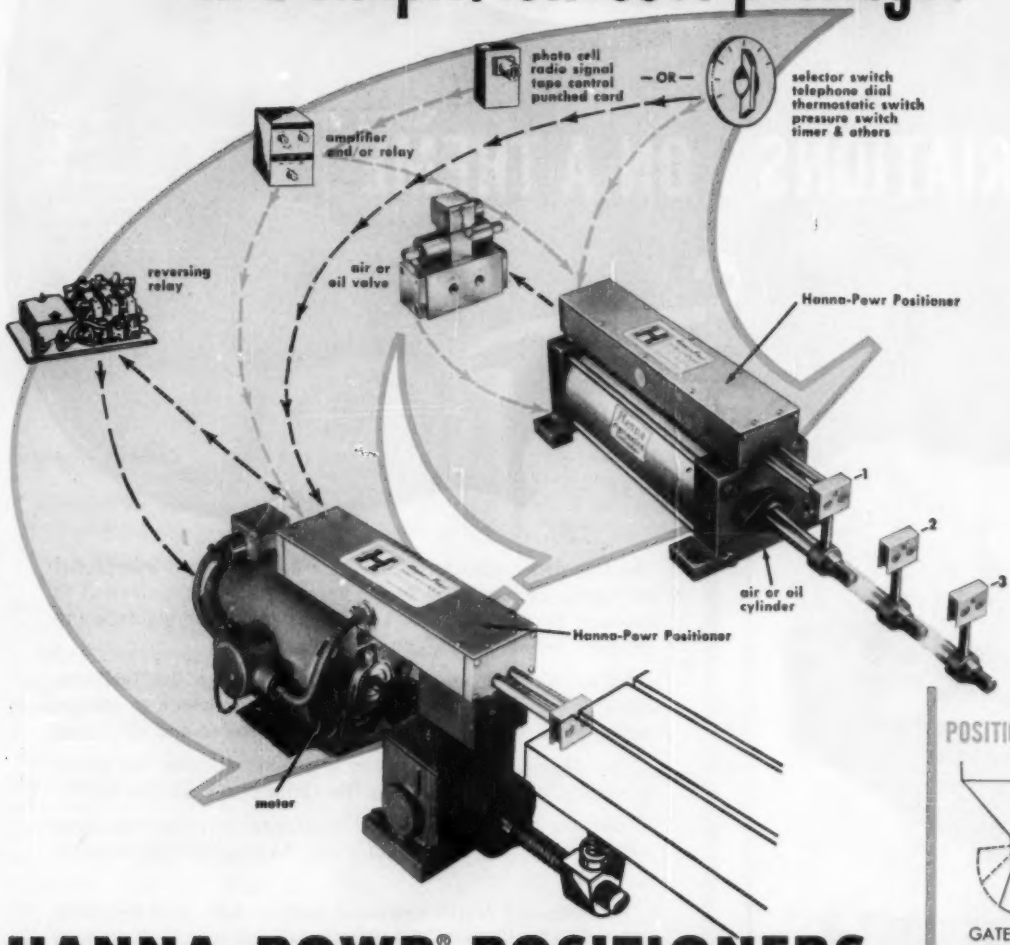
BRAND NEW IDEA... multiple positioning in a simple, low cost package!



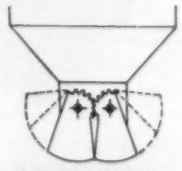
HANNA-POWR® POSITIONERS

THE NEW HANNA-POWR POSITIONER is a simplified, low-cost servo-mechanism used with air or hydraulic cylinders, electro-mechanical or other power drives to responsively achieve predetermined positions. The POSITIONER will also feed a signal to a read-out station to indicate the position point. Controls, such as selector switches, timers, thermostatic switches and others, feed signals to the POSITIONER for station selection—as many as 14 per foot of stroke. Infinite variations in positions are possible by simple movement of the adjustable limit switches. Stroke lengths may vary from a few inches to several feet to suit each application.

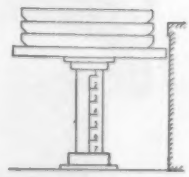
HANNA-POWR POSITIONERS save the time of designing special controls and cams, offer convenience of installation with one simple mounting for a group of controls, and cut maintenance costs by protecting all controls in a sturdy, dust-tight housing.

Your individual problems will suggest many uses for the HANNA-POWR POSITIONER. For more detailed information call your nearby Hanna Representative, (See "Cylinders" in the yellow pages), or write us for Catalog 500.

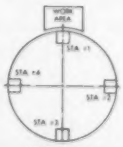
POSITIONED POWER



GATE POSITIONING



MULTIPLE POSITIONING OF LOADS



INDEXING

60 Years' Experience In Building The Finest Cylinders, Valves and Other Hydraulic and Pneumatic Equipment

Hanna Engineering Works

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prene concentrations in various solvent streams. Series 350 oxygen analyzer (illustrated) is available in single or dual ranges from 0-1 to 0-10 per cent oxygen and gives an output of 0-5 mv dc for recording or controlling with a potentiometer type receiver. Accuracy is ±2 per cent of the reading or better and speed of response is 95 per cent in less than one minute. Span gas valve and flow indicator are included in the instrument which also has an absolute zero. All three models are available in either explosion-proof type or standard sheet metal housings. **Analytic Systems Co.**, 980 N. Fair Oaks Ave., Pasadena, Calif.

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Alloying Furnace

Unit is suitable for highly critical alloying of electronic components, metal bonding and soldering, and similar exacting applications calling for extremely close temperature control through the 300 to 1100 C range. Model LAC-55M is essentially a box-type heating chamber with a special custom-built loading table at the front end, and a water-jacketed cooling section with drive mechanism at the discharge end. Principal design feature of this unit is a three-zone temperature control within the 36-inch heating chamber to obtain correct temperature curves for the particular work being processed. Special muffle construction through preheated atmosphere and temperature baffles insures uniform preheated dry atmosphere, balanced to prevent any creeping of temperature profiles. Controls are available to hold temperatures within ±½ C. **C. I. Hayes Inc.**, 808 Wellington Ave., Cranston 10, R. I.

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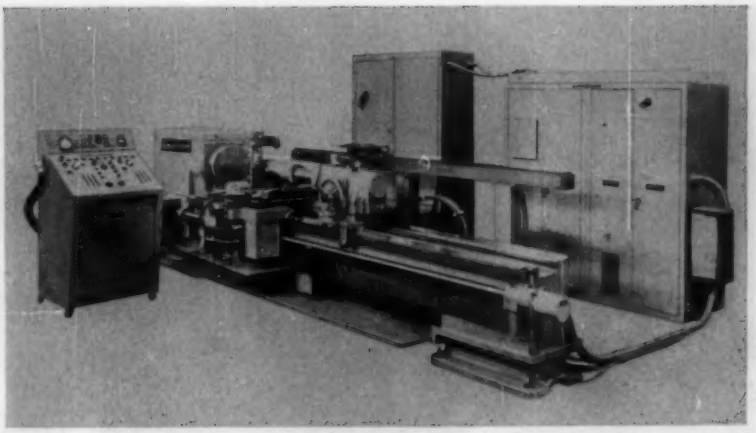

Tape and Tracer Controlled Lathe

Numerically and tracer controlled engine lathe is capable of doing step shafts as well as contours, fillets, radii, tapers, and other free forms. It combines an electronic duplicating system and a tape controlled discrete positioning system. Powered by 50-hp constant hp 4 to 1 variable speed main drive motor, this Model 2509 engine lathe has 20 spindle speeds in a range of 50 to 900 rpm. These spindle speeds are tape selected. Longitudinal and cross feed screws are both antibacklash ball screws. The lathe utilizes flat templates, and the tracer system is a 360-degree or 2-dimensional General Electric. There are 20 feeds with a range of ½ to 16 inches per minute. The lathe has an automatic indexing square tool turret with tape selected position. The front face of the turret will travel from a point 10 inches in front of center to a point 10 inches behind center. Numerical control is furnished by General Electric and utilizes 8-channel punched tape. Positioning of the templates is simplified by pushbutton control of the carriage and slide movement. **American Tool Works Co.**, Pearl St. at Eggleston Ave., Cincinnati 2, Ohio.

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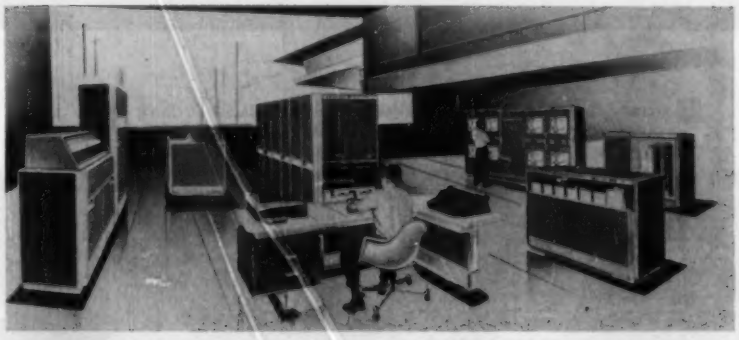

Data Processing System

The design of this completely transistorized information processing system permits a wide span of applications, from scientific computations requiring high speed but little peripheral equipment, to solution of complex business data processing problems requiring variety and quantities of peripheral devices. The computer can simultaneously handle eight different types of peripheral devices, such as magnetic and punched paper tapes, controllers, high-speed printers, card readers, and mass storage memories. It is capable of adding 25,000 five-digit numbers per second. Incorporating a newly developed gen-

1 MODEL 28 AUTOMATIC SEND-RECEIVE SET—facilities for sending and receiving messages plus tape preparation and reading, receiving in tape, integrating tape and manual keyboarding. Incorporates major components of Model 28 line in single, compact console—a "complete station."

2 MODEL 28 SEND-RECEIVE PAGE PRINTER—for sending messages by direct keyboard, receiving incoming traffic, providing print-out facilities. Sprocket feed, horizontal tabulator and form positioning arrangements available. Both this unit and the automatic send-receive set are equipped with the "Stunt Box," a built-in control and switching device.

3 MODEL 28 TAPE READER—advanced reader-distributor design permits (1) reading of punched tape for serial transmission; (2) reading of punched tape for simultaneous output on parallel-wire basis; (3) translating of electrical impulses from an external parallel-wire source for serial transmission. Available for 5 or 6-level code.

4 MODEL 28 TAPE PUNCH—receives incoming electrical signals, punches a 5-level tape and prints-out data on the tape. Used for message relaying, combining data from several sources on a single tape, or providing punched tape as a by-product of send-receive operations for input to business machines.

Teletype Model 28 Line...

standard units that offer flexibility, economy and reliability for message and data communications systems

The Teletype Model 28 line offers facilities to meet a wide variety of requirements in message and data communications equipment. It is an integrated line, designed on the modular principle, permitting flexibility in selection and interchange of components.

Speed is 10 characters per second for page units and typing tape punches—up to 20 characters per second for tape readers and non-typing tape punches. Page printers and tape punches can be adapted for parallel-wire input.

Exclusive with Teletype Model 28 page printers and automatic send-receive sets is the versatile "Stunt Box," a built-in mechanical memory device that is automatically activated by keyboard or line signals. The Stunt Box is used for internal control of "extra" features in the printer and external control of operations that can be activated electrically. It provides a simple, economical approach to station selection and many remote control problems.

The Teletype Model 28 line is specifically designed for continuous operation and very low maintenance. All-steel clutches and simple harmonic-design elements insure reliability and greatly reduce servicing needs. For example, the lubrication interval when operating at 10 characters per second is 6 months or 1,500 hours' operation, whichever occurs first.

Teletype Corporation manufactures this equipment for the Bell System and others who require the utmost reliability from their data communications facilities. Can be used with Data-Phone and other communications services.

More Information. Write for descriptive literature folder on Teletype Model 28 line to Dept. 26M, 5555 Touhy Avenue, Skokie, Illinois.

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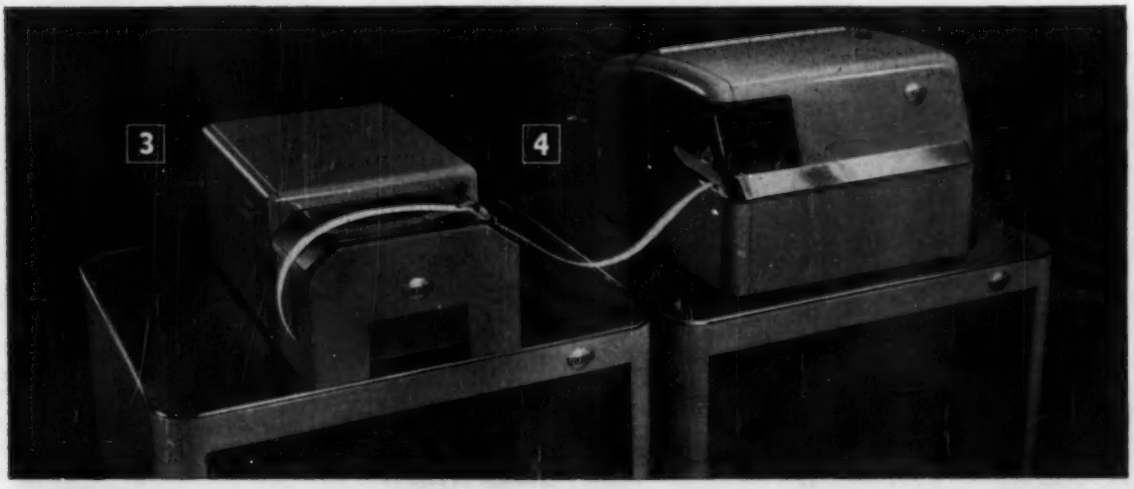

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eral-compiler programming technique, the unit automatically translates English words and symbols into machine language. The complete system includes a central processor (a control console, console typewriter, and card reader), a magnetic tape system, a card punch, a document sorter, a mass random access file memory, and a high-speed printer. All of the machine's operation codes are represented by mnemonic abbreviations. Special input-output devices can be used with the system for measuring and controlling temperature, pressure, and other process variables. The system combines the features of many large machines, such as unique circuitry, core memory, high-speed computation, low-power requirements, and ability to handle a large variety and quantity of peripheral devices. **General Electric Co.**, Computer Dept., Deer Valley Park, Phoenix, Ariz.

Circle 418 on Page 19

Small Parts Conveyor

Available to move coins, small parts, etc. from one level to another, small parts conveyor is available in 6 and 12-inch wide belts—4, 6, and 8 feet long. This neoprene belt conveyor is manufactured complete with special gearhead motor and switch. The ½-inch high solid rubber neoprene cleats are molded onto the conveyor belt. Sides are enclosed and the bottom is equipped with a tray to catch any spillage. The face of the belt is covered by a clear plastic shield and the return belt is enclosed in a metal casing. A steel hopper is equipped with a rubber flapper to prevent loss of parts and is attached to the lower end. **Sage Equipment Co. Inc.**, 30 Essex St., Buffalo 13, N. Y.

Circle 419 on Page 19

Lubricating System

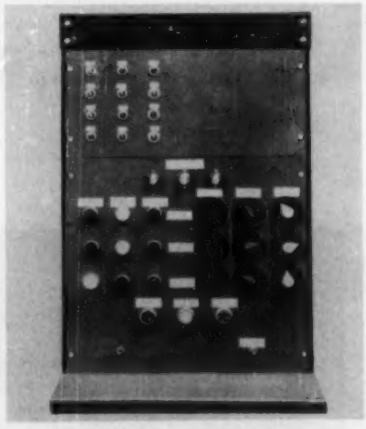
This system is designed to continuously circulate clean, filtered lubricant through machine bearings at controlled rates. It provides machine builders with a dependable means of centralized automatic lubrication which both controls oil circulation through machine bearings and allows for its reuse. Lubricant is pumped to bearings through the system, and returned by tubing or piping. Designated as Circulube, the system consists of a lubricator, a distribution system, and control units which determine flow of oil to bearings. A pressure signal switch prevents machine operation until proper oil pressure has been developed. Three basic lubricator models are available: CLFB unit has a two-gallon reservoir and a single outlet connection for continuous oil delivery; CLFC unit is equipped with a second outlet connection from which oil is delivered cyclically in small controlled quantities; CLWB (shown) is intended for small machines and is equipped with a single outlet connection and a half-gallon reservoir. All of the models are motor driven and include reservoirs with settling chamber and filter. They will operate satisfactorily at an inclination of as much as 30 degrees. **Bijur Lubricating Corp.**, Rochelle Park, N. J.

Circle 420 on Page 19

Wire Tying Machine

Conveyor-fed wire tying machine is designed for the automatic high-speed bundling of newspapers, catalogs, and other publications as well as for the reinforcing and closure of corrugated cartons and wooden boxes. Designated Model 3001 Autobinder, the machine uses 13 to 18 gage round steel strapping and can make up to 26 ties a minute with a 3½-twist tie. It will handle packages from 2 to 23 inches high and 8 to 36½ inches wide. Unit includes limit switch controls and a powered conveyor table. It requires a compressed air supply of 30 to 80 psi and 220 or 440 v, 60 cycle current. **A. J. Gerrard & Co.**, 400 E. Touhy Ave., Des Plaines, Ill.

Circle 421 on Page 19



Batching Control

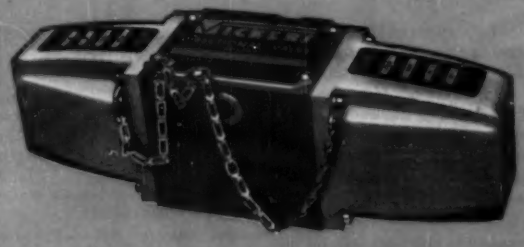
Control system has been developed to improve weighing efficiency and reliability in all types of applications involving the formulation of materials by automatic batching. It can provide either a scale for each ingredient or a common cumulative scale. A wide range of materials

Improved reliability • Greater capacity • No increase in price

NEW DIRECTIONAL VALVE DESIGNS

WITH VICKERS Q-E-L* SOLENOIDS

- New Q-E-L* solenoids assure quiet, cool operation plus shock-free performance through superior cushioning.
- Four to five times more cycle life than previously obtainable with ordinary air-cooled solenoids.
- Capacity increased from 50 to 500% on new designs.
- All models suitable for pressures to 3000 psi.
- Complete range of sizes available for maximum flows to 440 gpm.



MODEL DG4S4 is rated at 8 gpm (with nominal pressure drop) with a maximum allowable capacity of 12 gpm without malfunction. Maximum recommended operating pressure is 3000 psi. Standard subplates are available with ⅜ in. or ½ in. pipe thread ports. SAE straight thread port connections can also be provided.

MODEL DG5S4 solenoid-controlled, pilot-operated valve is rated at 30 gpm (with nominal pressure drop) with a maximum capacity of 80 gpm without malfunction, depending on circuit conditions and valve type. Standard subplates are available with ¾-in. and 1 in. pipe thread connections. SAE straight thread port connections can also be provided. Write for Catalog 5001-C.

8596

* Q-E-L designates Quiet Extended Life solenoid—a *Vickers exclusive.*

VICKERS INCORPORATED

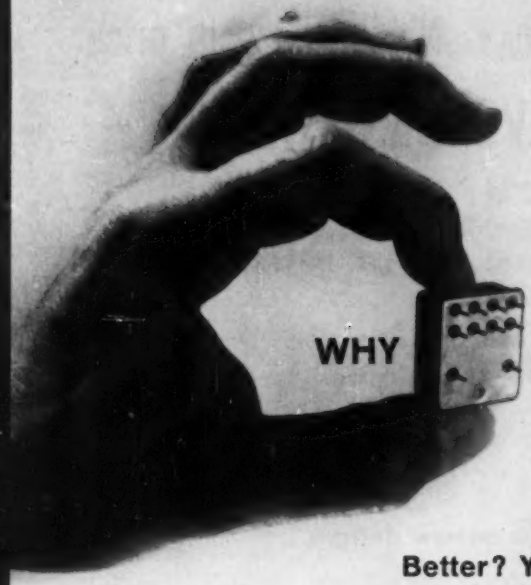
DIVISION OF SPERRY RAND CORPORATION

Machinery Hydraulics Division

ADMINISTRATIVE and ENGINEERING CENTER

Department 1536 • Detroit 32, Michigan

Circle 688 on Page 19



WHY THIS IS A BETTER *LATCHING* RELAY

Better? Yes, in several ways. Bifurcated Contacts, for example, give improved reliability, especially in dry circuits. Contacts will not open during vibrations of 30Gs, 55 to 2500 cps. A special method of sealing cover to base eliminates flux contamination of the contacts. And there are more. Here is Potter & Brumfield's newest member of a distinguished family of micro-miniature relays: the FL Series.

Expressly designed for printed circuit applications, this DPDT, 3 amperes (@ 30V DC) latching relay lies parallel to the mounting surface. Its height, when mounted, is only .485", thus circuit boards may be stacked closer. Mounting can usually be accomplished without studs or brackets, simplifying installation.

The FL will remain firmly latched in either armature position without applied power, a significant advantage where power is limited and long relay "on" times are required. This relay may be operated by:

1. Pulsing each coil alternately (observing coil polarity), or
2. Connecting the coils in series and operating from a reversing (polarized) source.

Write for complete information or call your nearest P&B representative.

FL SERIES SPECIFICATIONS

Shock: 100 Gs for 11 milliseconds. No contact openings.

Vibration: .195", no contact openings. 10 to 55 cps. 30 Gs from 55 to 2500 cps.

Pull-in: 150 milliwatts maximum (standard) at 25° C. 80 milliwatts maximum (special) at 25° C.

Operate Time: 3 milliseconds maximum at nominal voltage at 25° C.

Transfer Time: 0.5 millisecond maximum at nominal voltage at 25° C.

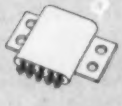
Temperature Range: −65° C to +125° C.

Terminals: Plug-in pins.

Dimensions: L. 1.100" Max.—W. .925" Max H. .485" Max. Hermetically sealed only.

SC 11 D

SCG 11 DC



SL 11 DB (Latching)

SLG 11 DA (Latching)

Other P&B micro-miniature relays include conventional and latching models in crystal cases with a wide range of terminals and mountings. All are made in a near-surgically clean production area under the exacting requirements of our Intensified Control and Reliability program.

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YOUR BEST SINGLE SOURCE FOR ALL MICRO-MINIATURE RELAYS

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

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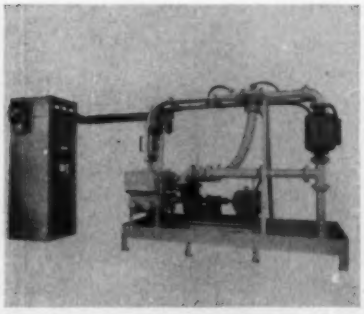
can be handled in broadly diversified industrial fields such as chemical and chemical processing, food processing, animal feeds, ceramics, ferrous and nonferrous metals, rubber, oil, and stone products. The direct digital system is completely compatible with the most modern control equipment, including computers, punch card programmers, and data logging to tape or printers. It utilizes the latest techniques in binary decimal language. A binary system for adding or subtracting weight from the beam uses but 4 weights per decade; only 12 set weights are needed to establish any weight over a range of 1 to 1000 lbs. Flexure pivots in three-point, nonredundant suspensions to prevent introduction into the system of unknown and unpredictable forces are employed. A parallelogram linkage with flexure pivots is used between weigh beam and the weight receiver platform. Accuracy of this control system is 0.02 per cent, repeatability, 0.010 per cent, linearity, 0.01 per cent, and sensitivity, 0.008 per cent. **Dynametrics Corp.**, Sales Dept., Northwest Industrial Park, Burlington, Mass.

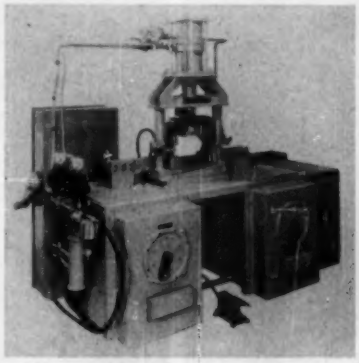
Circle 422 on Page 19



Tinning Line Simulator

Electrolytic tinning line simulator checks samples of metal for brilliance of tin coating. It simulates the tin line plating operation on a controlled, sample basis. A 6½ by 13¼ inch sample can be plated, reflowed, and tested. This system can also be used for fabricating a container for further experimentation and is ideally suited for establishing line parameters in the laboratory. The complete unit consists of an electrolytic circulating cell, a plating compartment and necessary dc power for plating. Electrolytic temperature regulation and velocity control is provided. Model 2971 includes a conduction reflow system with up to 1500 amperes conduction current available. It incorporates a brilliance comparator. **Designers for Industry, Inc.**, Process Instrumentation and Control Dept., 4241 Fulton Parkway, Cleveland 9, Ohio.

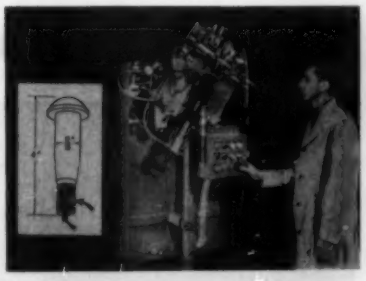
Circle 423 on Page 19



Projection Welder

Unit has the ability to encapsulate semiconductor and transistor components by resistance welding over a wide range of sizes (diameters ranging from 0.3 to 1.25 inches). This capacity range is made possible by the use of twin 75 kva transformers coupled to the welding head through balanced secondary circuits and a new welding head design. This welding head features two-column construction and a low inertia force system. It is mounted on desk-type subbase containing the welding transformers, electronic controls, pressure controls, and main disconnect switch. Welding force may be varied from 300 to 2400 lb and energized by 80 psi air. The two-column construction assures that electrode parallelism is maintained within 0.0001 to 0.0002 inches on 1¼-inch diameter work at full force. The twin transformers provide a maximum short circuit current of 64,400 amperes and have 16 pts. of heat regulation. They can be operated singly or in parallel. Electronic controls are grouped in two unitized cabinets. A load resistor is provided to insure consistent firing characteristics when welding small components. **Thomson Electric Welder Co.**, 161 Pleasant St., Lynn, Mass.

Circle 424 on Page 19



Inspection Machine

Unit has been developed to check the presence of a cotterpin hole and a screwdriver slot in a plain or threaded stud at the rate of 2500 pieces per hour, ejecting those without holes and slots immediately after inspection. Typical part piece shown in the photograph is a stud, front suspension-upper arm ball joint and lower arm ball joint. Four different size studs are checked on the machine through the use of interchangeable tooling. Controlled air flow detects the presence or absence of the hole. Screwdriver slot presence is checked with a probe operating against a limit switch. This type of detecting station is now being used in many automation transfer machines. **Instruments and Systems Div., Sheffield Corp.**, Dayton 1, Ohio.

Circle 425 on Page 19

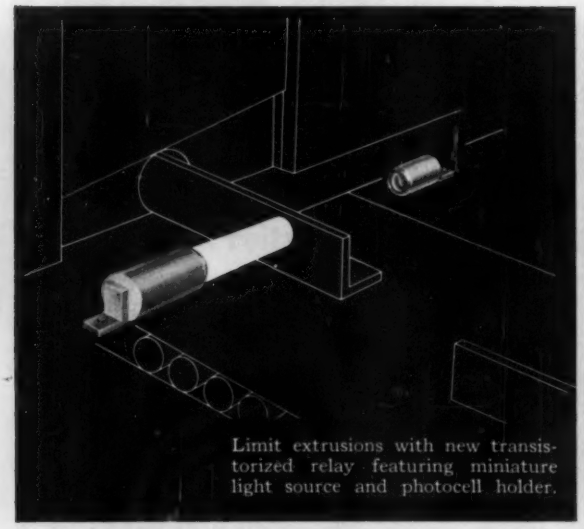
Tape Punching Adder

Consisting of a 10-key adding machine associated with a tape punch, this unit performs as a compact system for the preparation of

←*Circle 689 on Page 19*

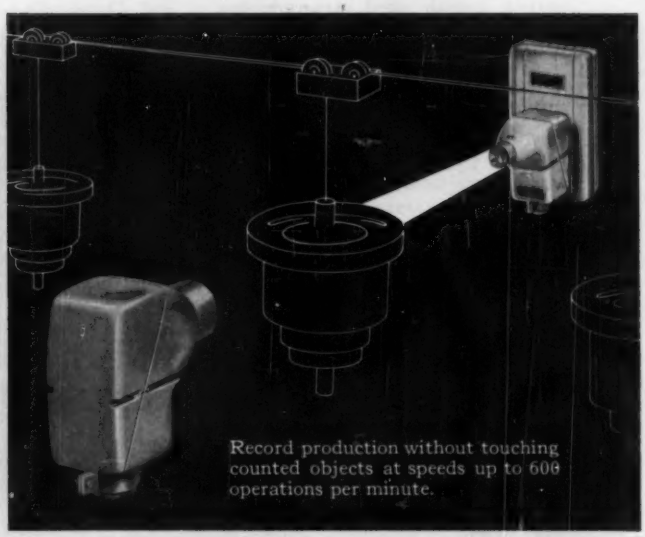
FOR QUALITY . . . PRODUCTIVITY . . . PROFIT . . . MODERNIZE WITH GENERAL ELECTRIC

LIMITING



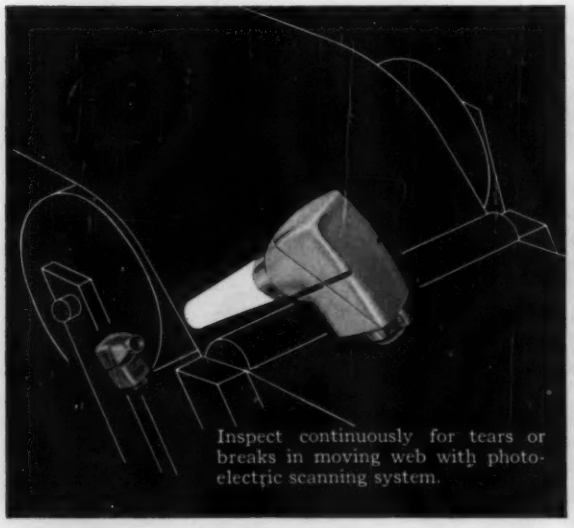
Limit extrusions with new transistorized relay featuring miniature light source and photocell holder.

COUNTING



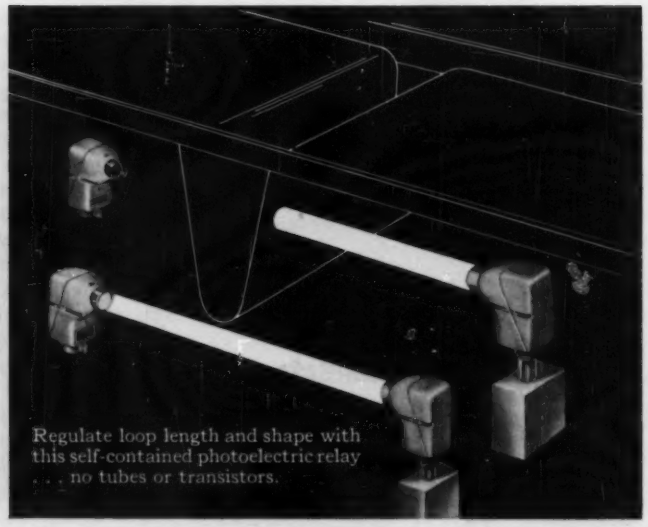
Record production without touching counted objects at speeds up to 600 operations per minute.

DETECTING



Inspect continuously for tears or breaks in moving web with photoelectric scanning system.

CONTROLLING



Regulate loop length and shape with this self-contained photoelectric relay . . . no tubes or transistors.

A COMPLETE LINE OF GENERAL ELECTRIC CONTROL DEVICES

Photoelectric controls
- General-purpose
- High-speed
- Long-distance

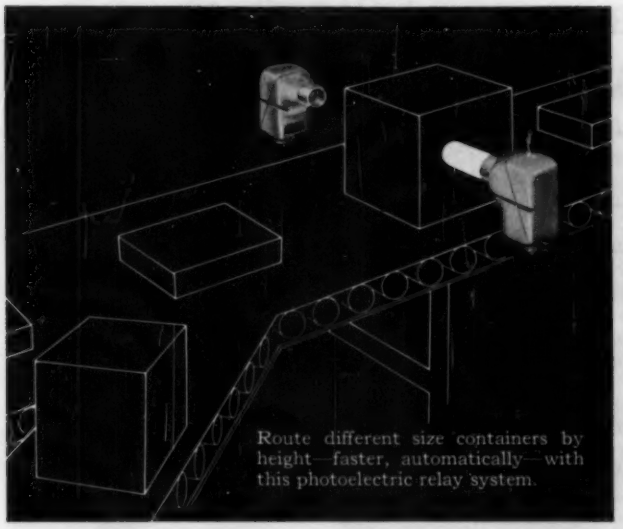
Electronic devices
- Timers
- Resistance-sensitive relays
- Voltage-sensitive relays

Photoelectric systems
- Smoke-density indicators
- Side-register controls
- Cut-off register controls

CONTROLS FOR AUTOMATION

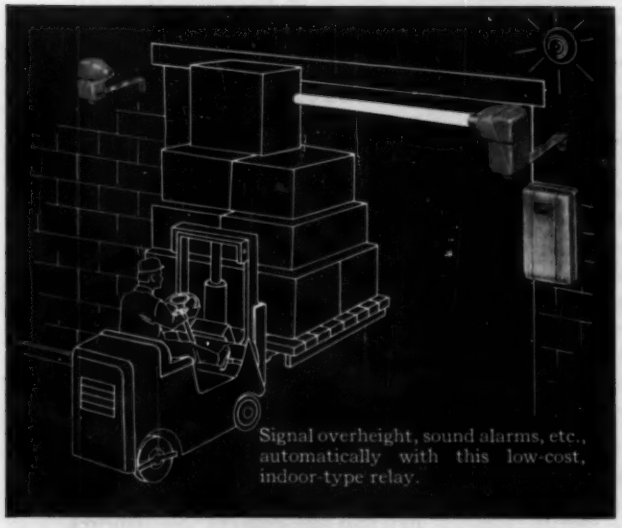
PHOTOELECTRIC CONTROLS

SORTING



Route different size containers by height—faster, automatically—with this photoelectric relay system.

SIGNALLING



Signal overheight, sound alarms, etc., automatically with this low-cost, indoor-type relay.

Switching . . . inspecting . . . counting . . . diverting . . . sorting . . . controlling. These are but a few of the *hundreds* of applications where General Electric photoelectric controls are helping our customers move closer to the benefits of automation—increased productivity, lower costs, higher quality.

Users are finding *new* ways to fit General Electric photoelectric devices into their production processes every day . . . for good reasons: These versatile G-E controls are designed for heavy-duty industrial use. They're easy to install, and require virtually no maintenance. They are highly dependable throughout a long operating life. In fact, General Electric photoelectric controls feature lamps with life expectancy of 10,000 hours—more than a year of round-the-clock operation!

ONE-YEAR WARRANTY, IMMEDIATE STOCK SHIPMENT

General Electric photoelectric and electronic devices carry a standard one-year warranty for your protection. And, your order for standard catalog devices is filled immediately from one of six regional warehouses. Also, replacement parts are warehouse-stocked, too, for your convenience and protection.

For expert help in applying General Electric photoelectric devices to your operations, call your nearby G-E Apparatus Sales Engineer or Distributor today. And, for your personal copy of our Photoelectric Devices catalog, mail the coupon below. *General Electric Co., Specialty Control Dept., Waynesboro, Va.*

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Fast, uniform, economical, safe

Just drill and install threaded pipe coupling in tank, then screw in the Chromalox Immersion Heater. Built-in thermostat automatically maintains uniform temperature of water, oils, paraffin, wax, various solutions. Several styles available, for different applications. Elements sheathed in copper or steel. Standard ratings from 50° to 550°F., ¾ to 10KW, 120 or 240 volts. Inside-tank extensions from 6¼" to 48". Available with explosion-resistant and moisture-resistant terminal box. Prices start under $20.

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DES MOINES, IOWA Cherry 3-1203
DETROIT, MICH. (See Southfield, Mich.)
HOUSTON, TEX. Capitol 5-0356
INDIANAPOLIS, IND. Melrose 5-5313
KANSAS CITY, MO. Victor 2-3306
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ROCHESTER, N.Y. Hamilton 6-7070
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meaningful analysis of business data. It provides for faster, more complete study of sales, cost accounting, inventory and payroll for both office and plant. Punched tape with 5, 6, 7, or 8 channels is produced at a rate of 20 characters per second. During all processes the unit supplies a printed detail tape for immediate accounting. The information on the tape may be programmed and analyzed within a firm or sent to various service bureaus for processing. **Victor Adding Machine Co.**, 3900 N. Rockwell St., Chicago 18, Ill.

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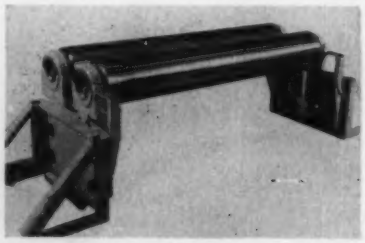


Tensiometer

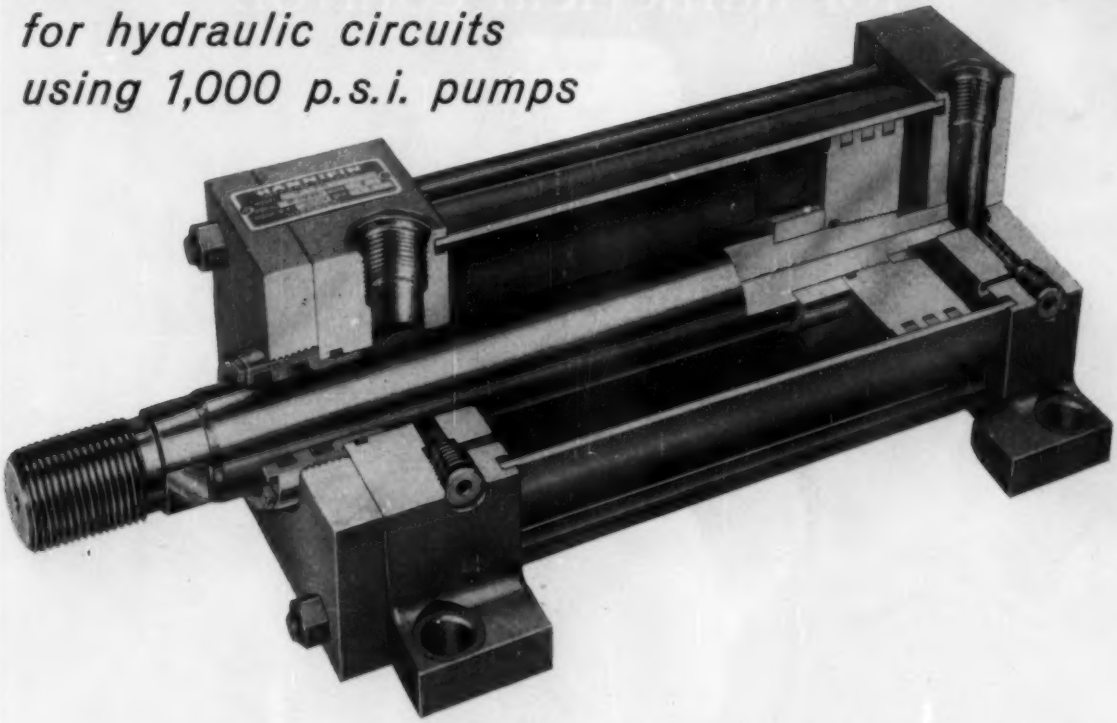
Indicating and regulating tensiometer has been designed for continuous direct measurement of strip tension in all types of cold rolling mills. It may be applied to mills of any width for accurate measurement of tension over a wide range at strip speeds up to 8000 fpm. When used with tension regulating circuits its output is suitable as a feedback signal for direct regulation of the desired rolling tension. Primary design feature of the tensiometer is the application of a pressure transducer as the tension measuring device. Maximum deformation of the unit is 0.002 inch from minimum to maximum tension thus eliminating the requirement for springs, hydraulic cylinders, and pivot points. The unit is available with three rolls to further increase its accuracy and eliminate errors caused by roll wear and mill pass line changes. Tensiometers will be installed on temper mills, Sendzimir mills, and tandem mills. Most of the designs are for use with tension regulating control which improves mill performance by increased accuracy of tension control. **Allis-Chalmers Mfg. Co.**, Milwaukee 1, Wis.

Circle 427 on Page 19

Circle 691 on Page 19

NEW FROM HANNIFIN
THE THOUSAND POUND LINE!

for hydraulic circuits
using 1,000 p.s.i. pumps



- *A true hydraulic cylinder — not a modified air cylinder*
- *Offered in nine bore sizes — 1" through 8"*
- *Every model withstands at least 1,000 p.s.i. in every bore size*
- *Built to save you money — yet not "built to a price"*

Now, for the first time in hydraulic cylinder manufacture, Hannifin offers a top quality cylinder tailored to the medium-high-pressure hydraulic circuits you operate off 1,000 p.s.i. pumps.

Series "L," the "Thousand Pound Line," is NOT a modified heavy duty air cylinder. It is built for the job . . . with steel heads and steel barrel for full compliance with J.I.C. hydraulic recommendations. Other extra-quality features include an induction hardened and hard chrome plated rod, nodular iron piston with cast-iron piston rings — leakproof "Lipseals®," optional — longer cushions on cushioned models, and the Hannifin-developed bronze cartridge gland with both "Lipseal®" and "Wiperseal" to keep the rod drip-free. S.A.E. straight thread "O" ring ports as recommended by J.I.C. are optional at no extra cost just as they are in the Hannifin heavy duty Series "H" hydraulic cylinder.

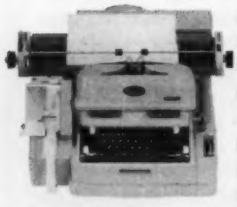
Parker-Hannifin field engineering service can help you meet your needs precisely, help you select the proper Hannifin cylinder for any service, air or hydraulic. Call your nearest Parker-Hannifin sales office or write direct for our new bulletin giving all dimensions of Hannifin Series "L" cylinders.

HANNIFIN COMPANY
A DIVISION
541 South Wolf Road • Des Plaines, Illinois
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

SOTT-FH

Is punched tape really the best input medium for numerical control?

(3 out of 4 machine tool makers say yes!)



Although 8-channel punched paper tape is only one of several numerical control input media, it is fast becoming the standard. Better than three-quarters of all builders of numerically-controlled machine tools now offer punched paper tape control. Why the swing to punched paper tape? There are three fundamental reasons:

1) Paper tape coding is visible, tangible. You can see it, touch it, and with practice even read it.
2) Paper tape is continuous. Unlike cards, it can't get out of order.
3) Paper tape is easy to program—preparation, verification, and reproduction of tapes are all handled on one inexpensive machine, the Friden Flexowriter® (illustrated).

For the machine tool buyer, standardization on paper tape means great savings. It's so much easier (and less expensive) when *one* input system can control *all* of the numerically-controlled machines in a given plant.

If you're thinking numerical control, you'll be way ahead to think *punched paper tape.*

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Circle 693 on Page 19

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For detailed information and literature, use card page 19.

Printed Contact Permanent Magnet Relay

DEVELOPED by the Components Div. of Executone Inc., 47-37 Austell Place, Long Island City 1, N. Y., this relay is specifically designed to save space and weight, reduce assembly time, and improve reliability. It is applicable to a wide variety of commercial and industrial equipment. Designated as Printact, the relay mounts directly on a printed circuit board. Intermediate connections to fixed contacts are eliminated by doing away with the contacts themselves. The moving contacts on the relay armature assembly mate directly with conductors on the printed circuit board. The conductor pattern can be designed to meet a user's specific application problem. The armature assembly carrying the moving contacts is held in position against one edge of a U-shaped fixed magnetic member by a small ceramic permanent magnet. Application of an electromagnetic field opposing the field of the permanent magnet causes the armature to rotate. The relay is accurately positioned on the printed circuit board by studs which pass through punched holes in the board. It is held in position by a simple flat spring clamp. Only the coil terminals require soldering. Preferred printed wiring base material is glass cloth epoxy although other materials may be used. Conductor material is 2-ounce copper, 0.0028 inch thick, and the contact areas should be plated with rhodium over nickel. Other board and contact materials may be used. Contact rating for minimum life is based on the recommended printed circuit board material and contact structure. Preadjusted, prestressed contact springs assure constant pressure. The solid molded magnet motor assembly serves as a dust cover for the entire contact system. Operating voltages with corresponding coil resistances (±10 per cent) are as follows: 6 vdc, 125 ohms; 12 vdc, 500 ohms; 24 vdc, 2000 ohms. Power consumption is 300 mw at rated voltage. Switching arrangements are 1, 2, or 3 pole single or double throw. Contact material is bar palladium, and maximum ambient temperature 70C. Operate time for the unit is 10 ms at rated voltage; dielectric test is 1000 volts rms 60 cps.

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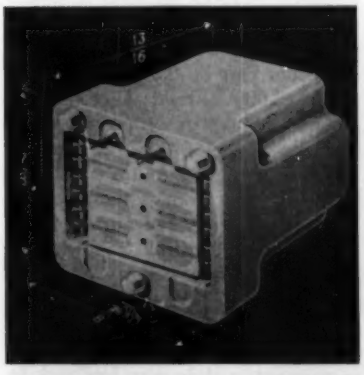
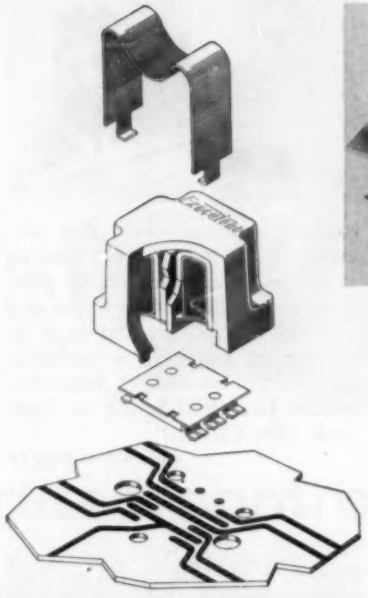
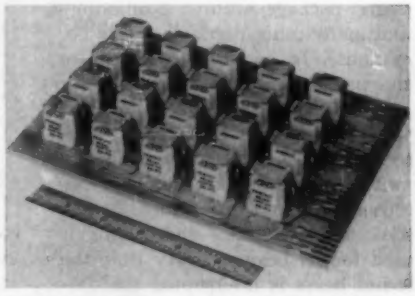


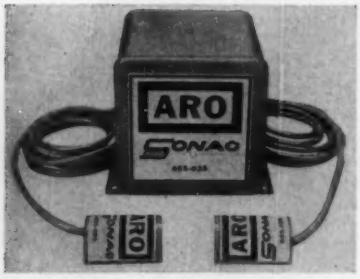
Printed contact permanent magnet relay is molded in high-impact plastic for direct mounting on printed circuit board. The armature and moving contact assembly consist of a No. 5 relay steel armature, a Mylar insulator, and heat treated beryllium-copper springs with bar palladium contacts.



Relay is accurately positioned on printed circuit board by three guide pins and holes in the board. A simple spring clamp holds the relay in position.



Individual memory module which registers up to 40 items of information has 20 printed contact permanent magnet relays occupying 8¼ by 5¾ by 1 inches of space.



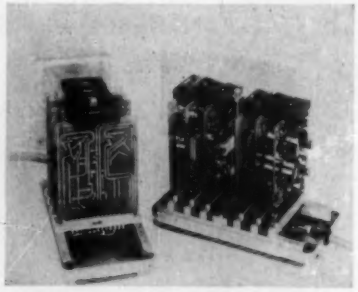
Ultrasonic Sensor

Automatic control and switching device, designated Sonac, uses beams of ultrasonic sound waves to count, control, or monitor. This unit is recommended for such diverse jobs as automatic counting, weighing, sizing, package routing, positioning, and many other production line operations. In addition to service on the production line, it is used for automatic industrial door and elevator control and for burglary protection. Basically, this sensing and switching system consists of two sensors and a control unit. Ultrasonic energy rather than light is used for its beam. Every time the sound beam is interrupted the control goes to work. Conditions such as vibration, dust and smoke, too little or too much light do not affect the device because it does not have to see objects. The control unit itself need not be installed in the same basic location as the sensors, since the ultrasonic beam can be piped through a tube to fit virtually any installation condition. The sensors are hermetically sealed and are suitable for weather-proof or explosion-proof operation. **Industrial Div., Aro Equipment Corp.**, Bryan, Ohio.

Circle 429 on Page 19

Signal Converter

Solid state analog-to-digital converter performs 3000 conversions per second. It is compatible with the analog signals produced by existing types of industrial transducers, and converts these voltages into three decimal digits in digital code format. Accuracy is 0.1 per cent ±5 millivolts. The unit may be used as an analog-to-digital converter with direct readout on any of several types of displays, or as a building block in a complex data handling or control system. It accommodates 5 volt full-scale dc signals directly, or millivolt signals through a single amplifier. Input impedance is 5000 ohms during the 150 microsecond conversion time, 20 megohms otherwise. Transducer loading is equivalent to 4 megohms at 10 conversions per second. Output signal consists of 12 bits, each of 10 volts at 50 milliamperes. Standard output code is 4-2-2-1 coded decimal; BCD or straight binary code is optional. Other code formats can be provided. Designated AN/DI, this instrument



contains a power supply that provides +10 volts ±0.1 per cent dc at up to 200 milliamperes for powering potentiometer transducers, and −10 volts +0.05 per cent dc at up to 100 milliamperes for providing zero offset to transducers. **Moore Associates Inc.**, 2600 Spring St., Redwood City, Calif.

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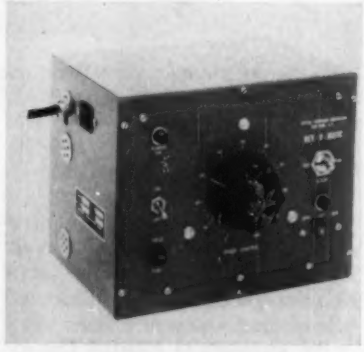
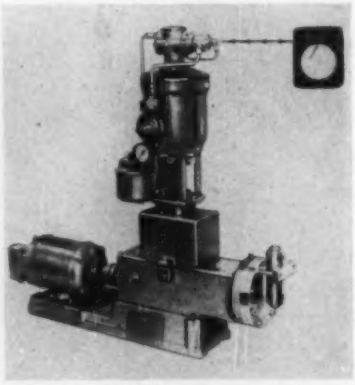


Variable Speed Controls

Units cover the 1/3 to 3/4 hp range. Their applications include use in process machinery, metal working machines, printing machines, material handling devices, and coil winding equipment. These electrical drives use no tubes, have wide speed ranges with stepless adjustment from zero to full speed, and utilize circuit breakers for armature protection. Remote control is light, small, and compact. **Applied Technology Corp.**, 475 Fifth Ave., New York 17, N. Y.

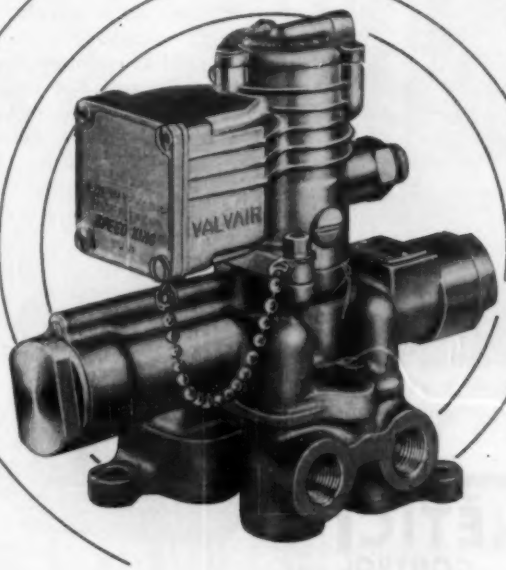
Circle 431 on Page 19



Metering Pump

Line of metering pumps with electronic controls is capable of handling corrosive and noncorrosive liquid chemicals. Pulsafeed pumps of this line are of the positive displacement type. They are offered in three types, a combination electro-pneumatic which uses air for power only (shown), an all-electric, and an electro-hydraulic. On the electro-pneumatic model, the actuator takes an electronic signal from a controller which in turn pneumatically operates an air cylinder. Supply air used to power the cylinder can be from 30 to 100 psi. The electronic input from the controller can be 0.5 to 5 milliamperes (3,000 ohms), 74 to 144 v (18,000 ohms) or other ranges as needed. The all-electric actuator model is designed to take an electronic signal from either remote manual adjustment of pump output or automatic control from an instrument. The power supply of this model is 110 v, 60 cycle, 40 w maximum consumption. For automatic proportional control, from an instrument, a slide-wire feedback in 135 ohms or 1000 ohms can be provided. Pumps fitted with the self-contained electro-hydraulic model actuator take a low level dc or ac input signal for positioning and use a standard electric power, single or three-phase, for actuation. Standard

No coil burnout with SPEED KING®



...pilot operated control valves

• Built to JIC standards • interchangeable pilots • choice of mounting types, optional features • ac or dc, any voltage • ¼ to 1 in. NPT

SPEED KING solenoid pilot coils, potted in molded resin, are unconditionally guaranteed against coil burnout for the life of the valve! And, Speed King pilots are totally enclosed, and sealed against entrance of dirt or moisture . . . valves are fully air-operated for speed and dependability . . . feature a hard-chrome plated stainless steel plunger floating in O-rings, to eliminate wear-producing metal-to-metal contact.

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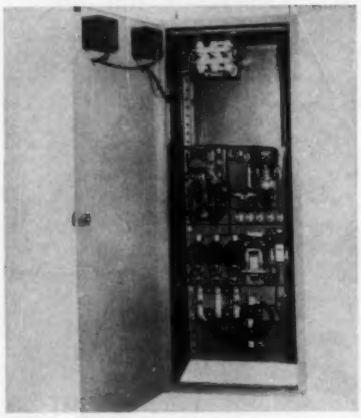
AKRON 9, OHIO
DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

Circle 694 on Page 19

signal range is 4 milliamperes dc. For ac input signals, a rectifier is supplied with the unit. **Process Equipment Div., Lapp Insulator Co.**, 116 Hall St., LeRoy, N. Y.

Circle 432 on Page 19

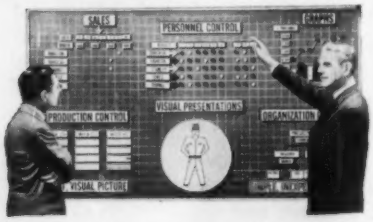


Motor Starter

Starter, designated Slipsyn, can be applied on all low and high-voltage synchronous motor starting equipment. Circuitry employs all static components and performs complex logic operations including application of motor-field excitation at both the proper speed and the most favorable rotor and stator relationship; detection and removal of exitation if the motor pulls out of synchronism; and protection of the starter or damper winding from over-heating when operating at subsynchronous speed. With this starter, the motor field can be applied accurately up to 99 per cent of synchronous speed. Pull-out protection is adjustable from 1 to 8 poles of slip. All power can be obtained from an ac supply. Several supply voltages can be used from a multitap primary on the supply transformer. For improved connections, a wirewrap technique is used during starter assembly. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

Circle 433 on Page 19

VISUAL
MAGNETIC
CONTROL



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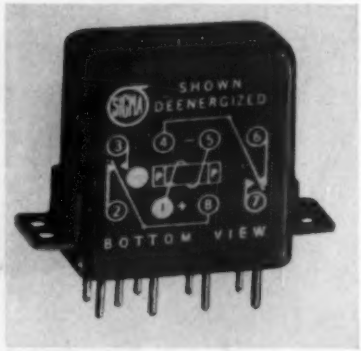
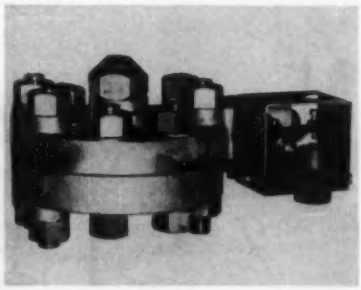
Circle 695 on Page 19



Subminiature Relay

Series 33 relay features a new 100-milliwatt adjustment. This adjustment, designated *VG*, has the following standard specifications: 30 g to 5000 cps vibration, 70 g shock and constant acceleration will not cause contacts to open, with relay energized or de-energized; −65 to 125C operating temperature range, and silver contracts rated at 2 amperes (28 vdc/120 vac, resistive load) for a minimum of 100,000 operations at 125C. This relay is especially applicable where relay compactness and dependable operation under extremes of vibration and temperature are required. It is available with dual coils, and gold alloy contacts rated at 0.5 amp for dry circuit applications. **Sigma Instruments Inc.**, 192 Pearl St., So. Braintree 85, Mass.

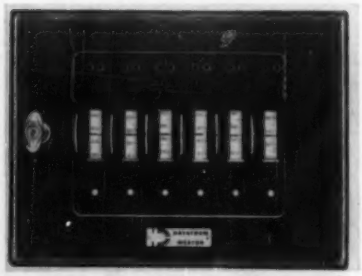
Circle 434 on Page 19



Pilot Valve

Differential-level pilot valve is not affected by variable system pressures. The valve operates on the difference between two columns of liquid, usually between a constant reference head and a variable head. As the level rises in the variable column the valve opens and releases air pressure from the top of a diaphragm motor valve, allowing the discharge of liquid from the variable column. When the level in this column falls to a predetermined level the valve again closes, and the cycle repeats. This principle can also be utilized with a steam trap to operate over an extremely wide range of pressures. **Besler Corp.**, 4053 Harlan St., Emeryville, Oakland 8, Calif.

Circle 435 on Page 19



Multipoint Controller

Nonindicating controller, Model 6134, with electric contact control combines two, three, four, five, or six individual measuring circuits and control circuits in one instrument with a common amplifier. It is ideally suited for control of electric heaters or valves for multiple zone furnaces, creep test machines, pilot plant, and research work. Two-position or three-position control is available as well as differential gap control. The dead zone on three-

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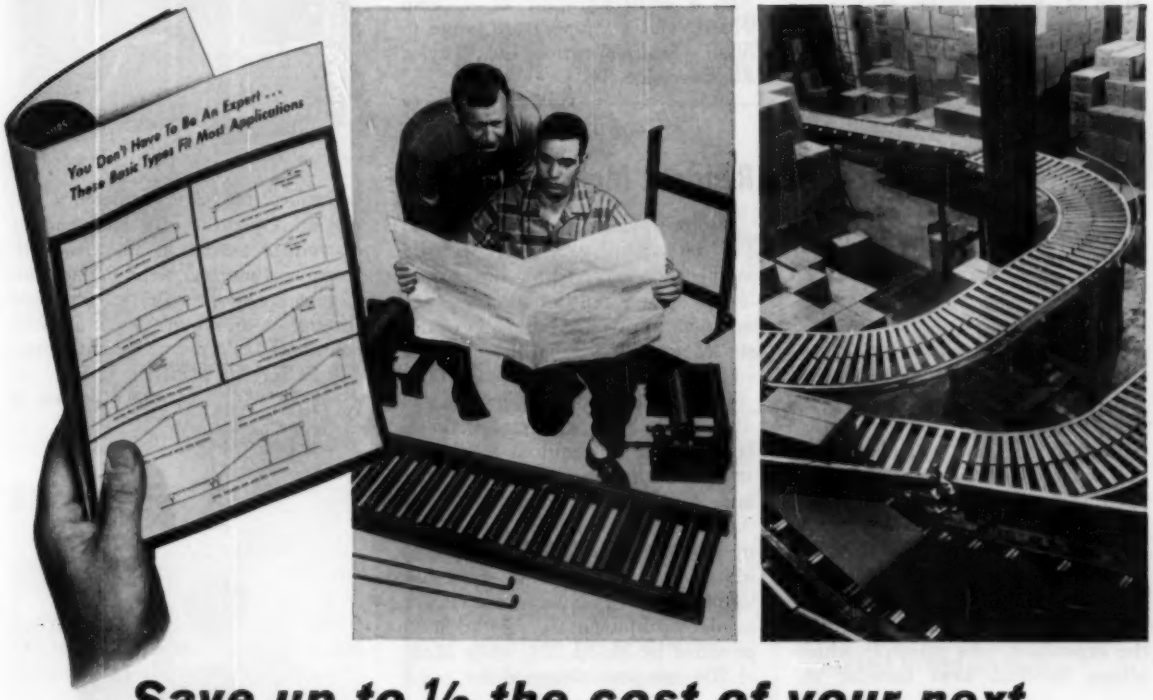

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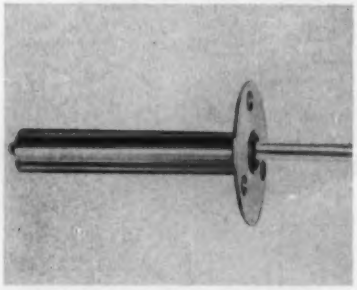
position and differential gap control is adjustable up to 50F or 1500 microvolts maximum. **Weston Instrument Div., Daystrom, Inc.**, 753 Main St., Poughkeepsie, N. Y.

Circle 436 on Page 19



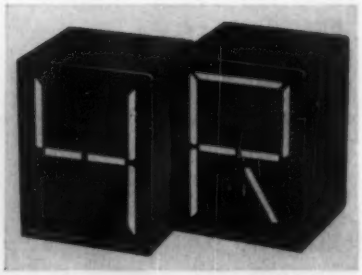
Temperature Switch

Unit is specially engineered for use where sensitive control is desired and space is at a minimum. Model D240 miniature tempswitch is 1½ inches in length and has a diameter of ¼-inch, flange ⅞ OD, and weighs 0.5 oz. It can be hermetically sealed, and operates on the expanding tube principle which allows for fast heat transfer response time. Setting tolerance of the tempswitch is approximately ±5F, depending upon the balance of the electrical circuit involved. It has a contact rating of 1 amp 115AC and a temperature range to 500F. **Scaico Controls Inc.**, Taylor St., Riverside, N. J.

Circle 437 on Page 19

Readout Modules

Alpha-numeric readout modules for data display systems feature momentary or latching operation. They operate entirely on electromagnetic principles and are designed for application flexibility in call boards, time table displays, tally and quotation boards, and similar display systems. The modules can be energized as required to display any letter in the English alphabet and any numeral from 0 through 9. Character size is 3 inches high by 2 inches across, affording visibility up to 70 feet in normally lighted areas. Two basic models are available. Momentary operation is provided by Model 203, while Model 204 has been designed for pulse



controlled latching or memory operation. Operation can be from any dc voltage from 1 to 30 volts, with response time less than 0.1 second. Connections to both types are made through a miniature type DB-25P connector. **Allard Instrument Corp.**, 146 E. 2nd St., Mineola, L. I., N. Y.

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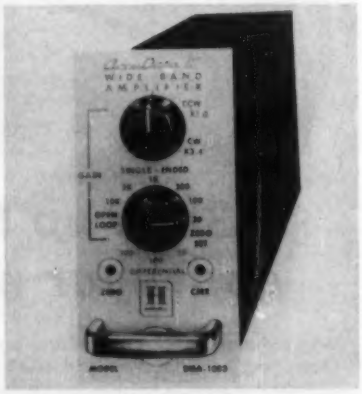

Direct Current Amplifier

Chopper-stabilized dc amplifier can step up low-level signals from a variety of transducers to 10 volts with a high degree of accuracy. Designated AccuData III, this all-transistorized unit has both single-ended and differential input connections. High output permits use of the instrument with standard A/D converters and allows use of higher source resistances in series with frequency, fluid-damped, light-beam galvanometers. Maximum gain is 34,000; input impedance is 20 megohms single-ended, or two megohms differential; output current is 65 ma at 5 volts, or 25 ma at 10 volts. Output impedance is less than 0.1 ohm. This amplifier is particularly useful in high-frequency data handling systems. The 10-volt output allows direct connection from transducer to a

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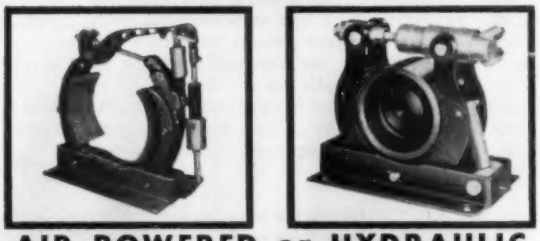
with Wagner



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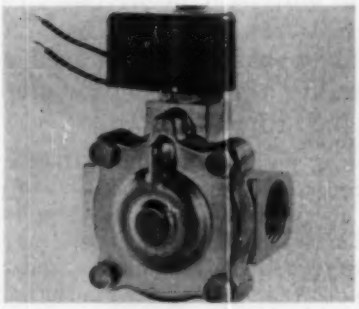
Circle 697 on Page 19

number of output devices, such as analog digital converters, high-speed oscillographs, high-speed printers, telemeter oscillator controls, and servo control valves. **Boston Div., Minneapolis-Honeywell**, 40 Life St., Boston 35, Mass.

Circle 439 on Page 19



Solenoid Valve

Two-way, general purpose solenoid valve has three operating parts. It is available with 1-inch pipe connections for either normally closed (valve closed when solenoid is de-energized) or normally opened (valve opened when solenoid is de-energized) operations. Model 8210A is tight seating and can suitably handle air, gas, water, light oil, and other noncorrosive liquids or gases at pressures from 5 to 125 psi. Requiring only 10.5 watts ac or 10 watts dc to operate, the valve may be provided in any voltage up to 550 volts ac, 60 cycles or 250 volts dc. **Automatic Switch Co.**, Florham Park, N. J.

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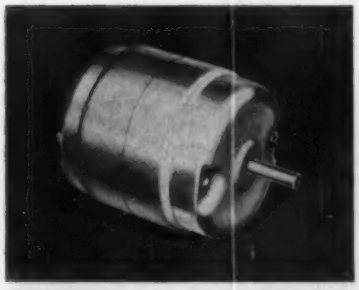


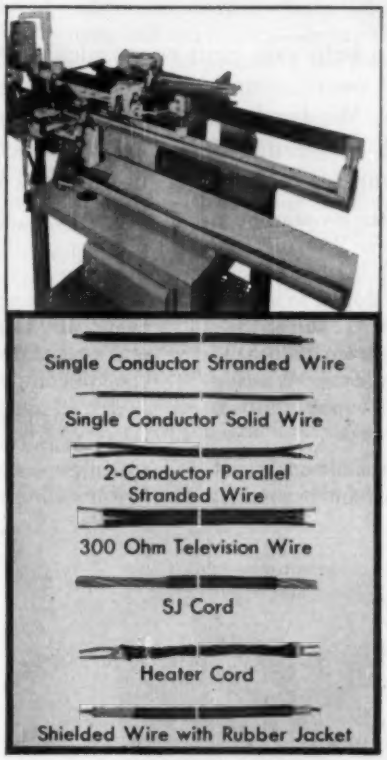
Shunt-Wound Motors

Two new models of series- or shunt-wound dc motors are available with or without radio suppression and may be used on blowers,

Another Time and Labor Saver

for finishing wire leads

with ARTOS AUTOMATIC CS-6



A new collecting device is now available for use on the popular Artos CS-6 wire-measuring, cutting and stripping machine. Illustration shows the new collecting trough (AE-478). Upper trough collects wire leads up to 60 inches long, then empties into the lower trough after wire has been cut, thus saving operator time.

Production speeds of 3000 finished wire leads per hour up to 15 inches long. Maximum cutting length is 194 inches . . . stripping up to 2 inches at one or both ends. Artos also makes machines that measure, cut, strip and *attach terminals* automatically at one or both ends.

Operated by unskilled labor. Errors and work spoilage, due to human element, are eliminated. Machines are easily set up and adjusted for different lengths of wire and stripping.

Proved performance. Time-consuming hand stripping jobs which once were a bottleneck in many plants are gone forever. As a result, Artos automatic wire strippers are paying their way in the mass production of television and radio sets, electrical appliances, motor controls and instruments of all kinds.

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Circle 698 on Page 19

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Westinghouse is ready now to help you plan economical steps to automatic production . . . to achieve your goals without over- or under-automating.

For many manufacturers, Westinghouse *Progressive Automation* has already proved a completely practical method of gaining improved product quality through step-by-step control of operations . . . a long-term plan with minimum capital cost for each step.

Now . . . automation step by step: Step-by-step automation can start with the modern Westinghouse controls, motors and drives at work in plants today. Each of these components was developed to achieve an immediate production objective . . . to control a single machine, a conveyor line or an entire installation. With this plan you then add other Westinghouse coordinating controls, all of which are compatible with those previously installed.

Benefits of long-term planning with minimum investment: First, you are meeting current production needs . . . improving productivity and/or raising product quality. Second, you are building a coordinated system . . . always ready for the next step in your long-range plan for automation. Your goal may eventually be overall production coordination under one master device . . . the Westinghouse industrial control computer.

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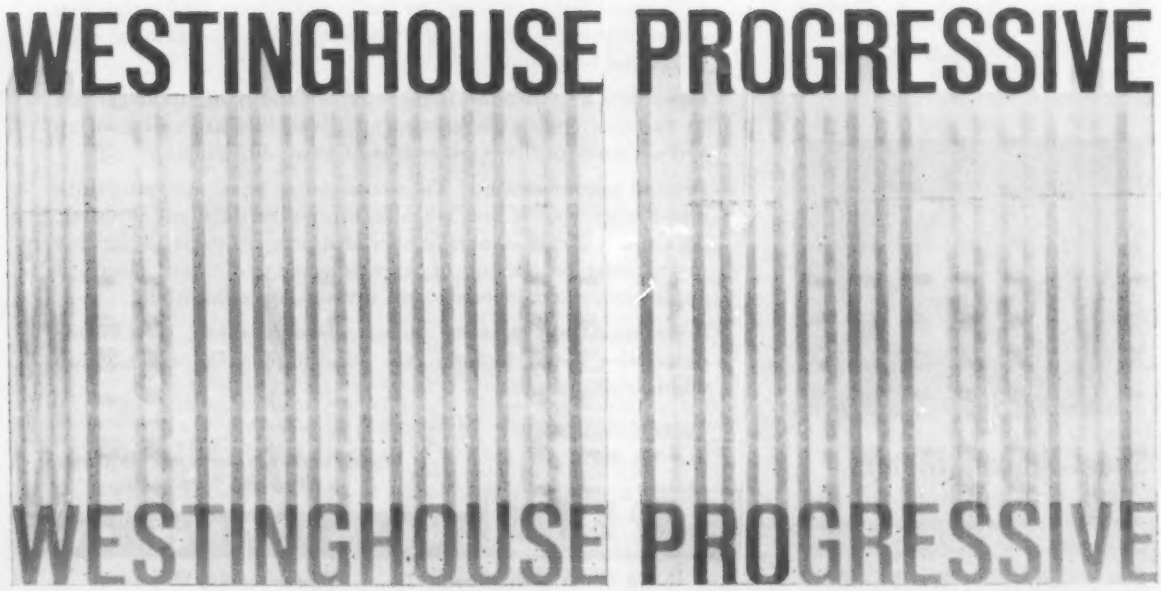


AUTO

AUTOMATION

MATION

Examples of Progressive Automation at work:

In the primary metals industry, installations of Westinghouse PRODAC* (programmed digital automatic control) have improved product quality and mill efficiency. This system has made possible automatic control of rolling mill functions, as well as monitoring all phases of the product and process by data accumulation systems.

Westinghouse industrial control computers are now being integrated with PRODAC to transform rolling mill equipment into a completely automatic unit. Three such systems are on order and underway.

In the paper industry, PULSETTER*, an automatic digital control system, makes possible new standards of accuracy and product quality in paper production.

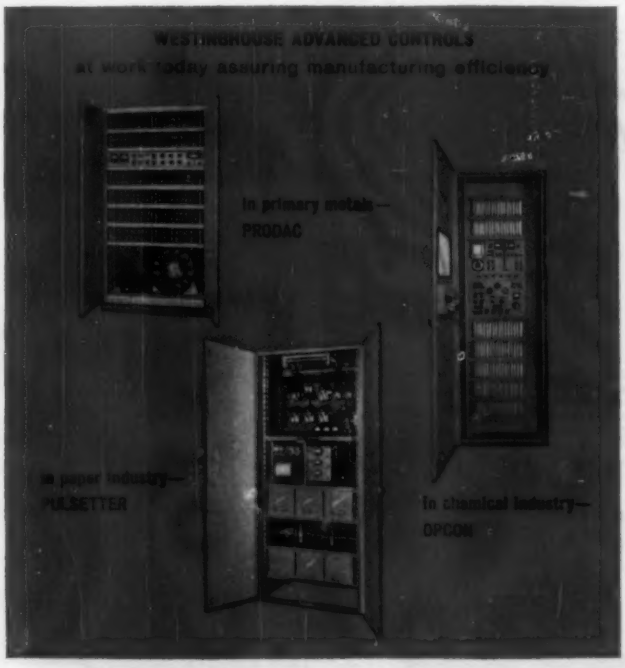
In the chemical processing industries, Westinghouse provides OPCON* which experiments, then finds and controls optimum production efficiency.

Let us know your objectives. Westinghouse is prepared to work out a long-range plan of progressive automation to provide your plant with the controls and other devices necessary to improve production. We are prepared to recommend, furnish, install . . . and maintain . . . all equipment to fulfill that plan. Call your local Westinghouse representative for complete information on *Progressive Automation*.

*Trade-Marks

Westinghouse Progressive Automation can help you Power-Up for Profit . . . Electrically

J-96139



YOU CAN BE SURE...IF IT'S **Westinghouse**

fans, hydraulic pumps, etc. They are built in totally enclosed, non-ventilated, die cast aluminum housings and are available for 6, 12, or 24 volt operation. Typical ratings are 1/40 hp, 3000 rpm; 1/25 hp, 5000 rpm; 1/3 hp, 4600 rpm; and 1/4-hp, 6400 rpm. **Universal Motor Div., Robbins & Myers Inc.**, Springfield, Ohio.

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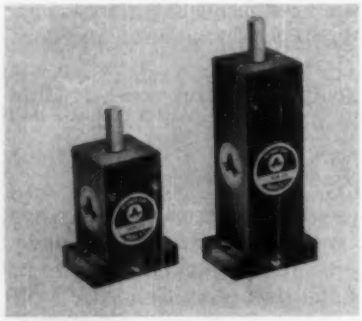


Air Clamps

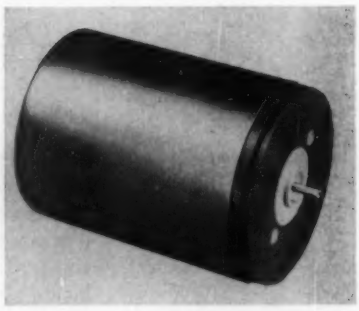
Spring return air clamps are available in two models, ACM-110 and ACM-120. Their sizes are respectively 1 1/8-inch bore by 1-inch stroke and 1 1/8-inch bore by 2-inch stroke. Their bodies are of Zamak alloy and the piston rods are of ground and polished stainless steel. Holes are provided both in the body and the base for either horizontal or vertical mounting. The clamps feature U-cup piston packing and oil type bearing for minimum friction. They have a one to one ratio of force to air pressure. **Allenair Corp.**, 255 E. 2nd St., Mineola, N. Y.

Circle 442 on Page 19

Phase Generator

Simple, accurate phase shifting is made possible by this electromechanical device. When excited with a fixed voltage at a fixed frequency, it produces a constant output voltage of the same frequency whose time phase is continuously controlled by and read from a dial assembly. Two such outputs are available which instantaneously differ from each other by 90 degrees time phase. Applications include phase measurement with an oscilloscope, phase measurement with a phase-sensitive demodulator, use as a reference for phase-sensitive devices, phase and amplitude measurement with nulling circuit, and use in servo-driven applications. The complete device is servo-mounted. Its output can be impedance loaded without adverse error effects. Specifications are as follows: Phase accuracy, 20 minutes; range 0 through 360 degrees continuous. **Theta Instrument Corp.**, 520 Victor St., Saddle Brook, N. J.

Circle 443 on Page 19



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★ Vertical and Way-Type Fixed Center Drilling, Boring and Tapping
★ Special Multiple Operation Machine Tools

Twenty-Station, Ten-Unit Transfer Machine for boring, counterboring, chamfering and valve clearance operations on V-8 automotive engine blocks. (Shown)

311

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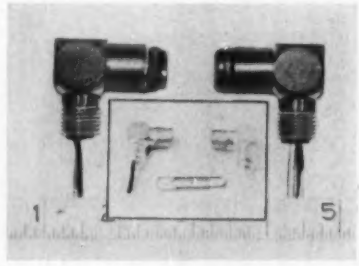
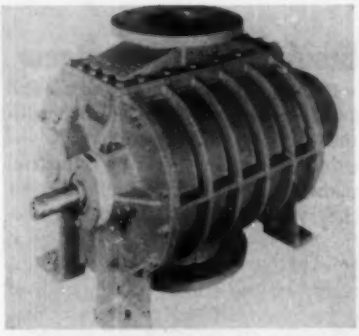


Photoelectric Units

Miniaturized photoelectric devices have been developed to offer industry a practical approach to monitoring, counting, positioning, etc., of any object passing or dropping through a light beam. They are small enough to fit into the palm of a hand and are provided with a 1/4-inch standard pipe thread for easy mounting. They may be used to operate relays when a direct light beam is interrupted by a passing object or arranged to operate on reflected light from a surface. A relay amplifier housing contains the power relay and associated electronic equipment together with a sensitivity adjustment and a light adjustment. By a proper adjustment of these controls, the relay may be set to operate at any desired threshold of light. For pre-

cise accurate control for registration, a self-contained unit of the reflecting type has been developed. This can be targeted to operate on very fine line or a sharp edge of color variation. **Photomation Inc.**, 96 S. Washington Ave., Bergenfield, N. J.

Circle 444 on Page 19



Rotary Blowers

Line of rotary positive displacement blowers is available in 2-inch through 8-inch gear diameters. They are made in three case lengths —L, M, and H—for most gear diameters. They can be either directly connected or V-belt driven. Design features of Series B rotary blowers are the addition of a thrust bearing kit on the drive shaft, steel gears, and dynamically balanced impellers. Units normally operate bottom inlet and top discharge, but can be reversed for bottom discharge if desired. **Sutorbilt Corp.**, Compton, Calif.

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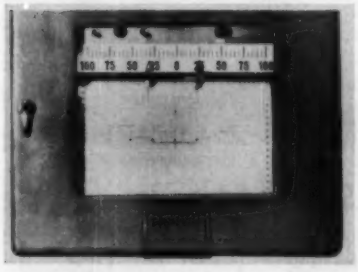

Strip Chart Recorders

Highly accurate single and twin pen strip chart recorders operate on continuous null balance principle; balance system involves two linear

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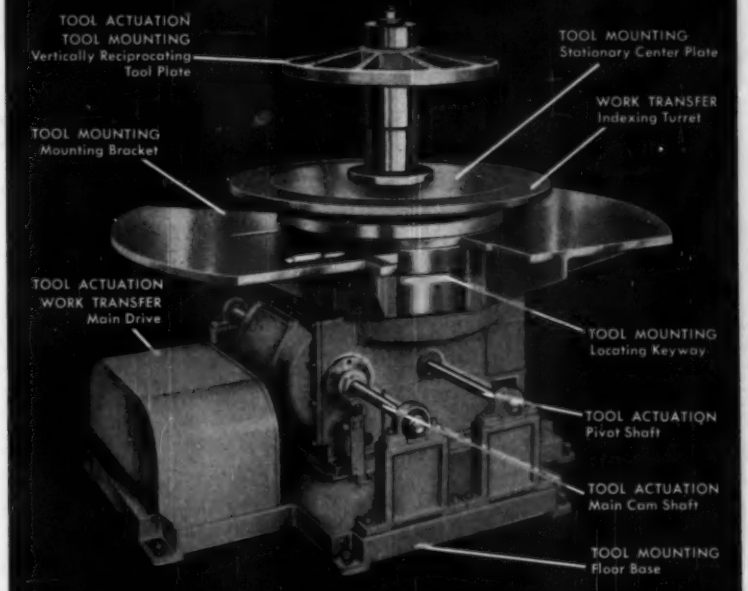

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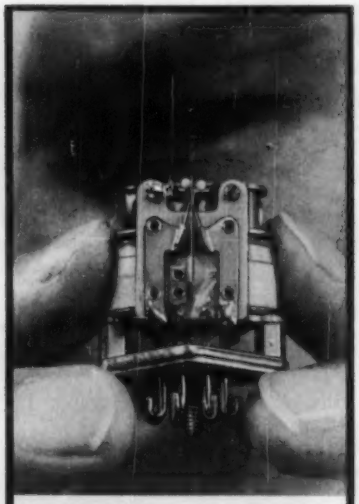

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RELIABLERELAYABILITY?

specify the VG and VGS series

Elgin's hermetically sealed VG and VGS miniature rotary relays provide high sensitivity and high contact rating in less than one cubic inch. The VGS Series operates on the power of a single transistor.

another example of relayability

VG AND VGS SPECIFICATIONS	
contact arrangement	DPDT (2 form C)
contact rating	5 amps @ 26.5 VDC or 115 VAC 60 CPS resistive load
min. oper. power @ 25°C	VG: 340 milliwatts VGS: 125 milliwatts
max. oper. time @ nom. oper. power	VG: 6 milliseconds VGS: 20 milliseconds
max. release time	10 milliseconds
duty	continuous
shock	VG: 100G VGS: 50G (MIL-R-5757C, shock test □)
vibration	10-55 CPS total max. excursion of 0.060 in.; 15G, 55-2000 CPS
amb. temp. range	−65°C to +125°C
life	100,000 operations @ rated resistive load (MIL-R-5757C)
enclosure	evacuated @ 2.5 in. HG ABS, degassed @ 10 microns and 170°C, dry nitrogen filled & hermetically sealed
dimensions	H−0.875″; W−0.875″; L−1.125″
weight	1.5 ounces

ELGIN RELAYS

2435 N. NAOMI ST., BURBANK, CALIFORNIA

Circle 702 on Page 19

variable differential transformers. Recorders can be used in indicating, recording, or controlling dimensional variables such as displacement, force, pressure, flow, and stress, as well as changes in dimensions of thickness, contour, extensometer, radial and linear acceleration, and strain. Specifications for Models MR1SL single pen and MR2SL two pen include: Sensitivity, a minimum of 0.005 inch of travel to drive the recorder full scale; chart speeds, 15, 30, 60 inches per minute standard; power, 115 volts, 60 cycles, 1 phase, 100 watts. **Schaevitz Engineering,** P. O. Box 505, Camden, N. J.

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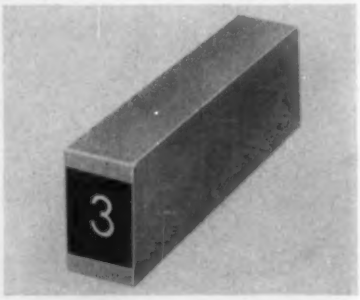

Decade Counter

Projection decade counter is capable of counting up to 100,000 events per second. It is designed especially for industrial applications where size, environment, and clarity of digits are of prime importance. Model PDC-1000 provides digits (zero through nine) readable at 30 feet or more and at angles of 120 degrees. Electronically self-contained and transistorized for rugged duty environments, this unit is suitable for fixed or mobile installations. Input power is 12 vdc at 240 ma; 20 vdc at 10 ma. Output signals are visual numerals 1½-inches high and 1-inch wide projected on a screen; or for preset counters, 6-volt pulses represent each count. Frequency is 0 to 100 kc. Triggering pulse amplitude and polarity are minimum 4-volts, maximum 12-volts; either positive or negative going pulses. Output impedance is 330 ohms. **Telemetrics Inc., Subsidiary, Arnoux Corp.,** 12927 S. Budlong Ave., Gardena, Calif.

Circle 447 on Page 19

Breakers and Switchgear

These 4160-volt breakers and switchgear are used by electric utilities—at power generation and distribution stations—and by industrial plants and commercial buildings for the switching, control, and protection of such equipment as motors, generators, distribution circuits, transformers, and a wide range of other electrical equipment and machinery. The breakers combine stored-energy closing and ironless blowout and afford fast fault interruptions and fast closing of contacts. Types of switchgear construction available include a conventional indoor arrangement, and two types of outdoor configurations—standard enclosed and full walk-in. **I-T-E Circuit Breaker Co.,** 1900 Hamilton St., Philadelphia 30, Pa.

Circle 448 on Page 19

Spacer Couplings

Units are equipped with special detachable hubs that permit the coupling of shafts spread as far apart as 7½ inches, depending on coupling size. They may be removed without disturbing shaft alignment. One application for which these Sure-Flex spacer couplings are especially suited is the con-

nection of motor and pump shafts. They will withstand great amounts of shock and vibration and take angular misalignment of 1 degree, paralled misalignment up to 1/16 inch, free end float up to 1/8 inch. Standard couplings range from a minimum stock bore of 3/8 inch to a maximum bore of 3 1/4 inch. Large size models are equipped with interchangeable tapered QD-type bushings. Smaller sizes with one-piece flexible sleeves are used for coupling of shafts up to 1 1/8 inch. **T. B. Wood's Sons Co.**, Chambersburg, Pa.

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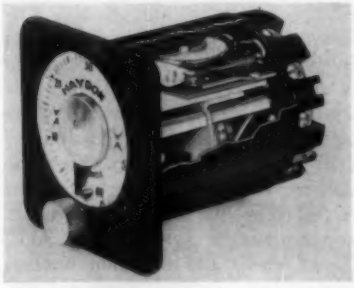
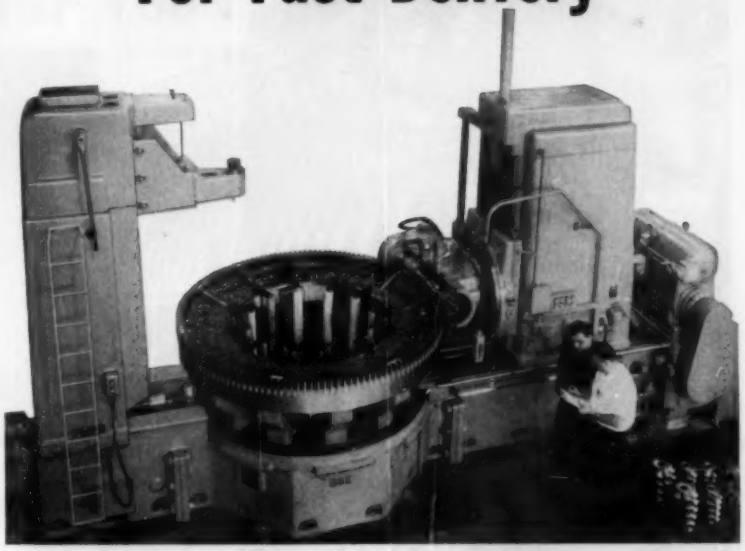


Clutch Reset Timer

Line of clutch reset timers combines the functions of delay and interval timers, opening or closing one or more switches after an adjustable period of time. These devices employ basic units to which various standard elements can be added to meet a wide range of physical and electrical requirements. Two principal physical timer variations are available: Series BR timers are designed for mounting in the rear of control panels, within control cabinets, and for other applications where the timing interval is changed infrequently; Series BP timers are designed for panel mounting. Designated as Acrotimers, the devices can be supplied with a single 15-amp SPDT load switch or with two 10-amp SPDT load switches. They can also be supplied with two relay switches, a 10-amp SPDT and a 10-amp SPST for momentary-contact actuation. All external clutch reset timers are designed for operation at 120 to 240 vac, 50 or 60 cps. Adjustable time ranges of 6, 15, 30, 60, and 120 seconds; 5, 10, and 30 minutes; and 1, 2, and 4 hours

New Production Capacity For Fast Delivery



Large Generated Gears

SPUR • HERRINGBONE • HELICAL

for a wide range of industrial applications

Gears which must operate smoothly and without vibration at higher speeds and under greater loads must correspondingly be more accurate in tooth profile and spacing.

H & S Generated Gears answer these demands.

Offering the same high-quality standards which characterize the complete H & S Gear line, production capacities for large generated Spur, Helical and Hobbed-Herringbone Gears are now available in the following dimensions:

Up to 80″ outside diameter at 1 DP
Up to 90″ outside diameter at 1¼ DP
Up to 100″ outside diameter at 1½ DP
Up to 125″ outside diameter at 2 DP
Face widths up to 42″, depending on helix angle

Send your specifications, or let our technical staff make recommendations. H & S specializes in fast production of quality industrial Gearing and Speed Reducers to meet your custom requirements.

Write for Catalog FLB-60

The HORSBURGH & SCOTT CO.
5112 Hamilton Avenue • Cleveland 14, Ohio

Circle 703 on Page 19

this drilling machine has 24 drives, 24 spindles, and

48 APEX covered universal joints

This giant drilling machine, engineered and manufactured by Michigan Special Machine Co., can drill 24 1-½" diameter holes in steel simultaneously. At each end of the shafts that connect the 24 individual drives and spindles is an Apex 3" diameter *covered* universal joint.

These 48 joints permit lateral movement of the spindles to conform to any desired drilling pattern. In addition, the *exclusive* Apex flexible cover provides clean, sustained lubrication that complements the automatic lubrication provided for the ways and other moving parts of the complete unit.

Apex heavy-duty universal joints combine size, strength and durability without sacrificing precision. Apex industrial universal joints, ¼" to 4" diameter, covered or uncovered, are available in a full range of hub types and can be built to order from bronze alloys, stainless steels or other special materials required for specific types of service.

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or write, on your company letterhead please, for Catalog 28 and Data Sheet. For special applications, send sketch or print for prompt recommendations and quotation.

THE **APEX** MACHINE & TOOL CO.
1638 South Patterson Blvd.
DAYTON 2, OHIO

Phantom view of Apex universal joint with lubricant-retaining cover, an exclusive Apex development. Apex covered joints operate efficiently in wet, dry, corrosive or abrasive atmospheres and

Circle 704 on Page 19

can be supplied. **Haydon Div., General Time Corp.**, 245 E. Elm St., Torrington, Conn.

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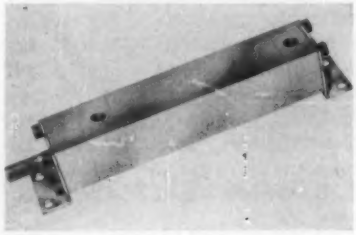

Square Barrel Cylinders

Line of air and hydraulic cylinders perfectly square on the outside with each of their four sides flush and flat is available for range of mounting possibilities. Their all-square sides, blended with their square heads, make it possible to drill and tap along the length of the barrel for mounting purposes. A full selection of interchangeable attachments is available for foot, flange, clevis and trunnion mountings, and many combinations. Double acting square barrel (Class 7) cylinders can be obtained in diameters of ¾, 1, 1½, 2 and 3 inches. **Galland-Henning Nopak Div.**, 2753 S. 31st St., Milwaukee 46, Wis.

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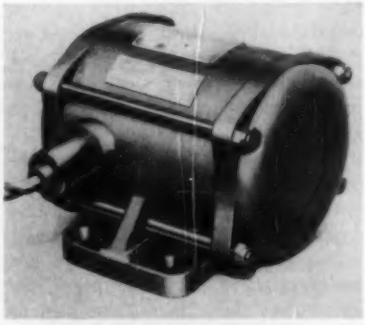

Electric Vibrator

Explosion-proof electric vibrator for moving stubborn materials through bins, chutes, and hoppers is ideal for use in atmospheres containing natural gas, gasoline, naphtha, and similar vapors. It uses no pulleys, belts, or springs, and delivers 3600 vibrations per minute with 60 cycle current. Vibration

force is produced by eccentric weights which are fastened on each end of the rotating motor shaft. Vibration impact from 385 to 1100 lbs with seven separate settings can be obtained. Model RC-32 is available in three phase ac current either 220 or 440 volts, with an input of 500 watts. **Cleveland Vibrator Co.**, 2828 Clinton Ave., Cleveland 13, Ohio.

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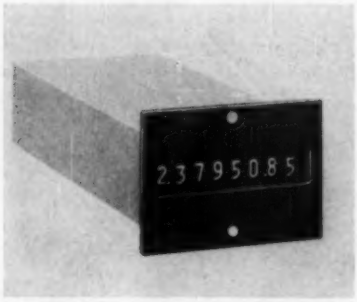

Impulse Counters

Seven and eight-digit totalizing electric impulse counters are available in two counting speeds—25 impulses/sec and 10 impulses/sec designated Models TCe7E and TCe8E respectively, both totalizers have the same compact dimensions, 1.653 by 1.220 by 4.370 inches. They are suitable for flush mounting. Power requirements are low, using only 1.6 watts at 24 v dc for 10 impulses/sec models. **Landis & Gyr Inc.**, 45 W. 45th St., New York 36, N. Y.

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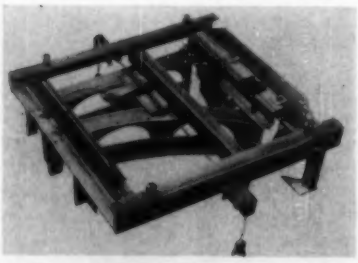

Track Switches

Overhead track switches, designated Types K and L, are designed for loads of 2000 to 4000 lb capacity. They are made for left-hand, right-hand, and three-way operation; for

TOLEDO SCALES that PRINT Complete Weight Records for You . . .

. . . *THE ANSWER* to prevent "guesswork" and errors in cost control!

Toledo Printweigh Scales are available in a full range of models, including Built-in Hopper, Tank, Overhead Track and Motor Truck Scales, in addition to the models illustrated above.

Human errors in reading, remembering and recording weights are eliminated with Toledo Printweigh "400" Scales. They're the surest way to satisfy your requirements for weight records that are complete and indisputable.

Weights are printed in full figures, even when unit weights are used. Choice of printing on 8½" x 11" forms, or on tickets; also on strips. Weight data may be transmitted electrically for recording on remote adding or other office machines. "Memory" feature available for printing weight data, even after load is removed.

Toledo Printweigh "400" Scales give new flexibility and efficiency in weighing . . . to cut costs, guard quality, prevent profit-stealing weighing errors. Ask your Toledo representative for the full story on Printweigh Scales, or WRITE TODAY FOR BULLETIN 2017. TOLEDO SCALE, Division of Toledo Scale Corporation, Toledo 12, Ohio
(Toledo Scale Co. of Canada, Ltd., Windsor, Ont.)

"MISFIT" SCALES MULTIPLY COSTS

Scales can become "misfits" as a result of changes in plant layout, materials handling, inventory controls, value or quantity of materials weighed. If this has happened in your plant, the results can be costly. For example: weighing errors, production bottlenecks, materials handling inefficiencies. Be sure your scales are adequate for the job. Ask your Toledo representative about a scale adequacy check in your plant, or send for the Toledo Weight Fact Kit.

SERVICE

TOLEDO® *Headquarters for Weighing Systems*

Circle 705 on Page 19

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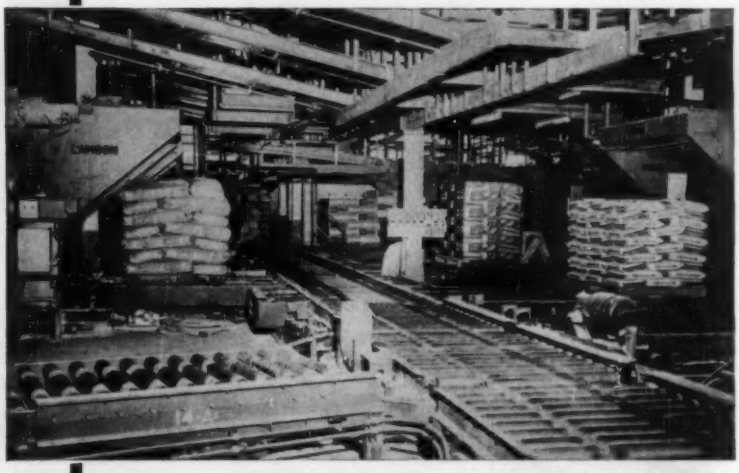
WITH LAMSON ENGINEERED CONVEYOR SYSTEMS



Automatic Palletization — the hub of a LAMSON engineered conveyor system linking production lines to warehouse.

You cut production time and the unnecessary handling of materials to the bone with the help of LAMSON engineers. They are specialists in developing materials handling systems that truly increase the capacity of your present buildings and dramatically increase the productivity of your present equipment.

There are more LAMSON custom engineered conveyor systems in successful operation today than any other kind. They are being serviced throughout their life by the same LAMSON field offices that initially analyzed the problem, proposed the solution and supervised the installation.

As a result of this complete, professional service you will find many of the finest names in industry among LAMSON installations. During the past 75 years LAMSON has been active in almost every field, yours included, and perhaps even in divisions of your own firm. LAMSON can cut costs; speed production; increase your profits.

If you have a materials handling problem, write LAMSON today for our conveyor catalog and the name of your nearest LAMSON Field Engineer. Or, simply clip this advertisement to your letterhead and mail to:

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LAMSON CORPORATION

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Manufacturers of Airtube® (Pneumatic Tube Systems) • Integrated Conveying Systems • Pallet Loaders • Selective Vertical Conveyors • Bookveyors® Clinical • Trayveyors® • Food Service Systems • Blowers and Exhausters • Exidust® Central Vacuum Cleaning Systems • Dryset® Air Vacuum Systems

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manually-operated and motor-propelled systems. They may be shifted by hand, electric, or air power. As a feature, the inner track-carrying frame rides on antifriction rollers. A strong latch mechanism holds the switch firmly in position. Safety guards are provided to prevent carriers from running off open ends of incoming rails. **Cleveland Tramrail Div., Cleveland Crane & Engineering Co.**, Wickliffe, Ohio.

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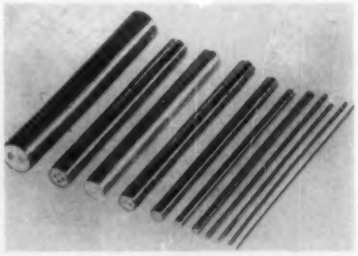

Thermocouples

Line of metal sheathed thermocouples is designed especially for rapid, accurate, economical temperature sensing applications. Features include easy attachment to thermocouple heads or connectors, high resistance to thermal shock and severe pressures, and good thermal conductivity. They can be imbedded or cast in virtually any material. Several standard junctions and special junctions are available in a variety of configurations and standard cold end terminations. **Harco Laboratories Inc.**, New Haven, Conn.

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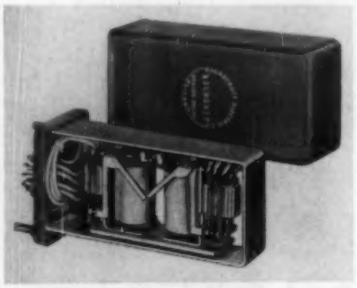

Latch-In Relay

Enclosed miniature latch-in relay requires only 2-1/16 by 1½ inches of panel space. Designated Class

11LHS, the unit consists of two complete miniature type relays mounted together. Armatures of the two relays are mechanically interlocked so that the energizing of one relay latches it in and releases the other. Operating voltages or currents as well as contact arrangements of the two relays can be entirely different. The relay is available hermetically sealed or with removable cover for dc continuous or intermittent duty with up to four form C contacts per relay and for ac intermittent duty with up to two form C contacts per relay. It can be furnished with miniature solder terminals with up to 27 pins or with miniature plug-in headers with up to 20 pins. **Magnecraft Electric Co.**, 335 4D W. Grand Ave., Chicago 51, Ill.

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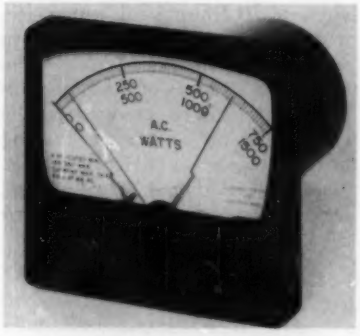
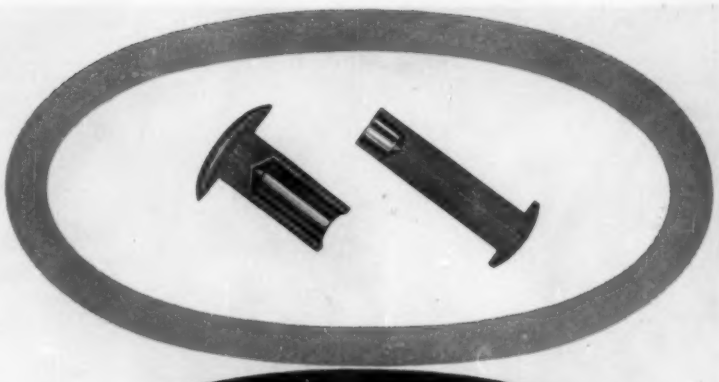
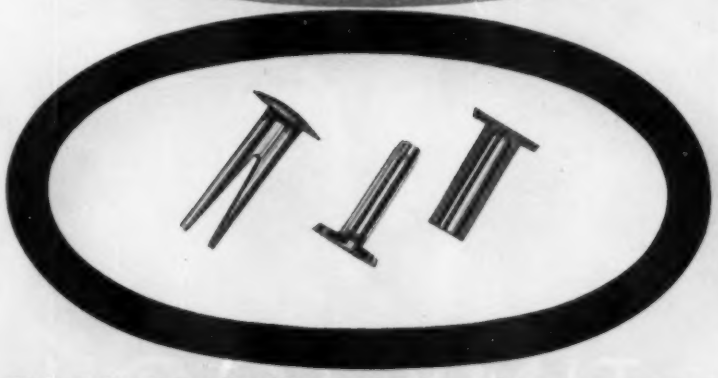


Monitoring Wattmeter

This ac-dc contact making wattmeter is also available in a modified form as a true rms voltmeter or ammeter, or as a varmeter. Capable of both indicating and controlling power in the lower milliwatt range, it can monitor the product of as many as four different variables. Standard full scale sensitivity is 500 milliwatts, either ac or dc. With modifications dc ranges as sensitive as 100 milliwatts are available. The instrument can be built to operate on any ac frequency up to 1000 cps. Either ac or dc must be specified; they cannot be measured interchangeably by a single instrument. The wattmeter is available with any of the standard API circuits used with locking contact meter-relays to provide a variety of control patterns. When remote indication or control adjustment is desired, the meter-relay and associ-





COST PREVENTION...NOT COST REDUCTION...IS THE EFFICIENT WAY TO LOW-COST ASSEMBLY

The "in-place" cost of a fastener is what really counts to cost-conscious production men. By deciding on inexpensive Milford tubular rivets as a fastening method and installing them with Milford automatic rivet-setting machines, design and production engineers are eliminating costs at the initial production stage rather than trying to reduce costs later at the assembly line.

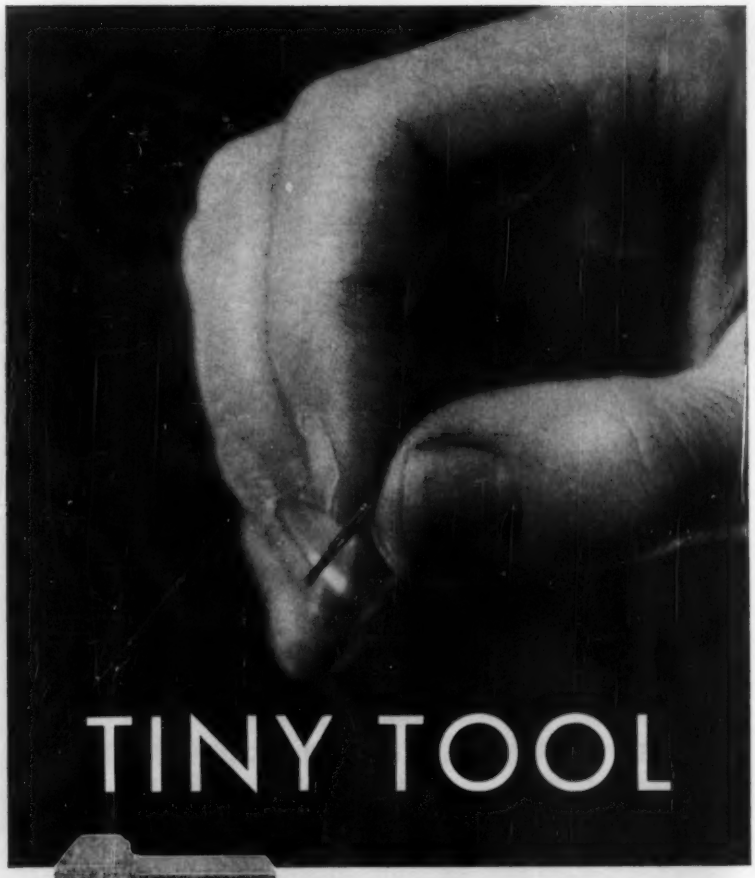
You can find out more about Milford's cost-cutting ideas by asking your Milford Representative to show you Milford's new MANUAL OF MODERN RIVETING PRACTICE. It's crammed with valuable cost-cutting tips and technical data that can be quickly translated into dollars on your production line.

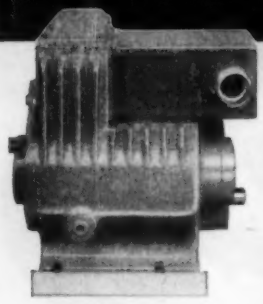
THE MILFORD RIVET

MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • NORWALK, CALIFORNIA
ELYRIA, OHIO • AURORA, ILLINOIS • HATBORO, PA

Circle 707 on Page 19





Seneca Falls Mechanical Power Amplifier with two phase Servo Motor as control input device.

MACHINES EXTRUSION DIES AUTOMATICALLY

With "muscle" supplied by the Seneca Falls Mechanical Power Amplifier and "brains" supplied by a two dimensional tracer system, this tiny tool machines the minute openings in dies for extruded moldings. A .020" diameter stylus point traces the intricate shapes required. Hand work is eliminated.

The Seneca Falls MECHANICAL POWER AMPLIFIER is a simple, power servo drive in striking contrast to the more complex electrical and hydraulic devices. Years of Service in rugged applications prove its dependability, long life and negligible maintenance.

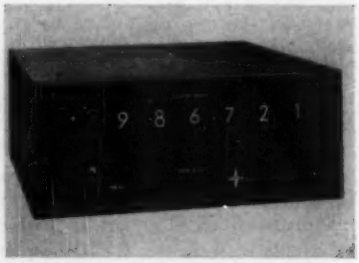
Whatever your control problem, investigate this simple, easily maintained Power Servo Drive that will amplify torque from *any* control input device. Its excellent dynamic response permits the design of high sensitivity control systems. Write for Technical Bulletin EE 1009.

SENECA FALLS MACHINE
PIONEERS IN AUTOMATION

SENECA FALLS, MACHINE CO.
ELECTRONICS DIV. • SENECA FALLS, N. Y.

ated circuitry are furnished in two packages for separate mounting. **Assembly Products Inc.**, Chesterland, Ohio.

Circle 457 on Page 19



Linear Display System

Series 100 Modumatic linear display system provides readout of actual cutting tool or workpiece position. Utilizing an analog-to-digital shaft encoder, this system is absolute. It features full range electronic origin selection and built-in self-checking circuits. Specially designed for all types of machine tools used on small-lot production, the system can be adapted to existing machine tools on a retrofit basis. **Norden Div., United Aircraft Corp.**, Data Systems Dept., 3501 Harbor Blvd., Costa Mesa, Calif.

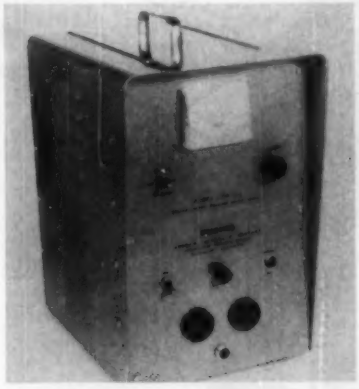
Circle 458 on Page 19

Indicator Lights

Miniature neon transistor driven indicator lights are capable of operating on very low supply voltages and have a minimum life of 25,000 hours (with NE-24 at 0.5 milliamperes lamp current). Typical applications include battery operated test equipment, portable transistorized equipment, and any system where

voltages would normally be too low to operate neon lights. LVN Tec-Lites feature a self-contained transistor oscillator circuit which converts low dc voltage to ac, stepped up to the voltage supply required for operation of the neon. Lamps are available with two terminals for a steady glow and three terminals which light only upon application of an input signal. Operating temperature range is from −40 to +65 C. Power consumption is 150 mw nominal. The lights are designed for single nut mounting in 3/8-inch hole on 5/8-inch centers. This series includes five standard models covering a supply voltage range of 6 to 24 vdc. **Transistor Electronics Corp.**, 3357 Republic Ave., Minneapolis 26, Minn.

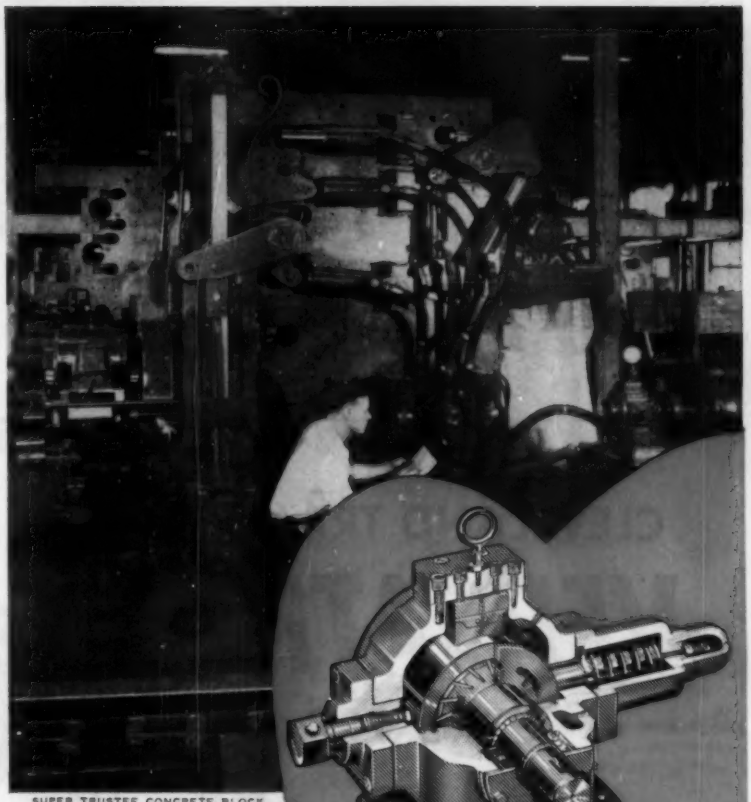
Circle 459 on Page 19



Welding Power Supply

Designed especially for miniature electronic welding, this 40 watt-second stored energy welding power supply delivers a step free adjustable range of power of 0.01 to 40 watt-seconds in 0.001 of a second. It can be used with any weld head handpiece or fixture with only three connections to be made. A pulse width of one millisecond assures no burning or discoloration of material. Weld speeds are up to 120 spots a minute. The power supply is packaged in a cabinet occupying less than one square foot of bench space. Each Model VTW-29 is ready to plug into any 110 to 120 v dc line supply. **Vacuum Tube Products Div., Hughes Aircraft Co.**, Marketing Dept., 2020 Short St., Oceanside, Calif.

Circle 460 on Page 19



SUPER TRUSTEE CONCRETE BLOCK MACHINE BUILT BY THE GENE OLSEN CORP., ADRIAN, MICHIGAN

This dependable hydraulic heart

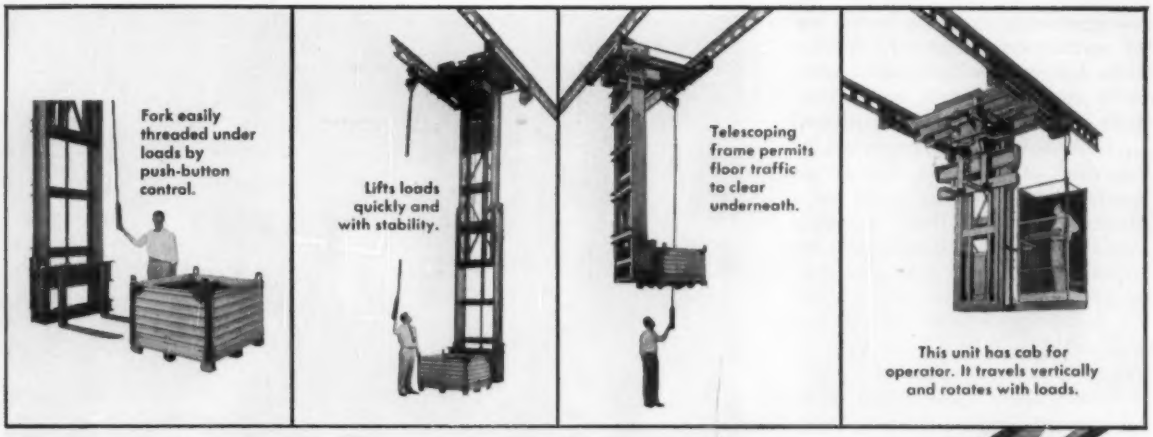
The heart of this 1100 blocks per hour concrete block machine is a RACINE MODEL 8R PUMP

REDUCES UPKEEP AND DOWN-TIME BY AS MUCH AS 80%

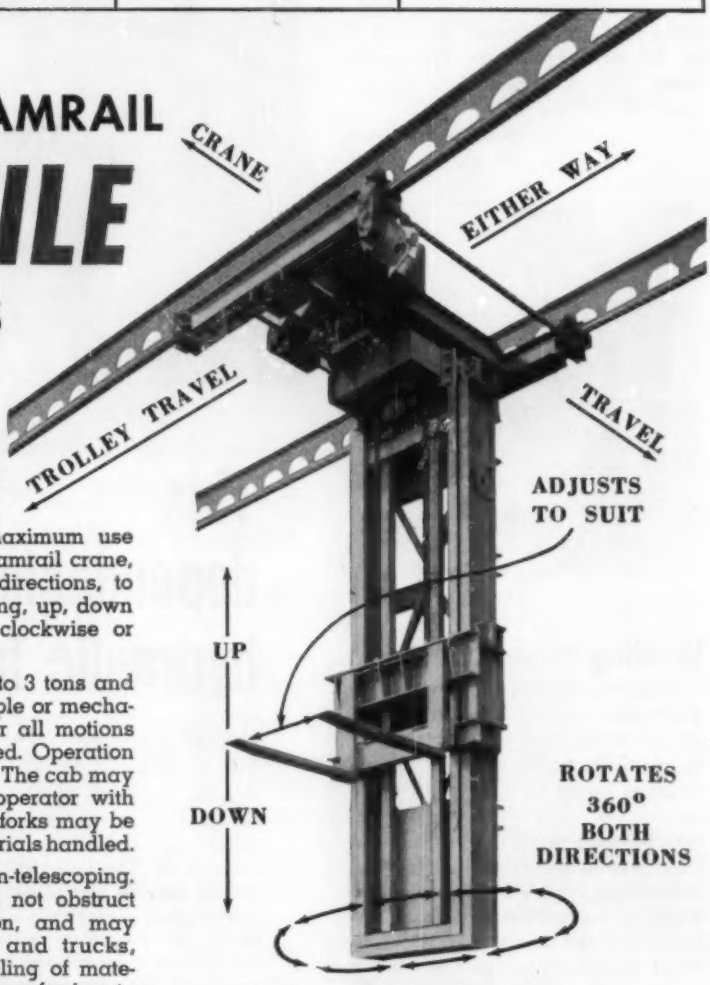
"RACINE HYDRAULIC EQUIPMENT is the *heart* of our concrete block machines," says C. S. DeLamater, sales manager for The Gene Olsen Corp., another satisfied user of RACINE PUMPS and VALVES exclusively since 1949. Besides the tremendous savings in operating hydraulically-designed concrete block machinery, the firm emphasizes the advantage of simplified control of oil circulation in RACINE VARIABLE VOLUME PUMPS. They pump *only* the oil required to do the job — no waste of pressure oil — no heating. Thus through lower horsepower, operation economies are enjoyed.

RACINE **Racine Hydraulics & Machinery, Inc.**
RACINE, WISCONSIN
HYDRAULICS DIVISION

Circle 709 on Page 19


Fork easily threaded under loads by push-button control.
Lifts loads quickly and with stability.
Telescoping frame permits floor traffic to clear underneath.
This unit has cab for operator. It travels vertically and rotates with loads.

CLEVELAND TRAMRAIL VERSATILE STACKERS



THE maneuverability of Cleveland Tramrail stackers enables obtaining highly efficient handling coverage of a warehouse with maximum use of space. When on a Cleveland Tramrail crane, a stacker can be traveled in all directions, to front, rear or either side of a building, up, down and turned through a full circle clockwise or counter-clockwise.

Stackers are available for loads to 3 tons and lifts to 20 feet. They may be as simple or mechanized as the work requires. Any or all motions may be manually or power operated. Operation may be controlled from floor or cab. The cab may be traveled vertically to provide operator with maximum visibility of work. Lifting forks may be designed and spaced to suit the materials handled.

Design may be telescoping or non-telescoping. Telescoping type (illustrated) does not obstruct aisleways when in raised position, and may be traveled over railroad cars and trucks, thereby permitting the direct handling of materials to storage without need of transferring to other conveyances.

Cleveland Tramrail stackers and supporting cranes have much to offer. They can be designed to exactly suit your needs. Why not have a nearby Cleveland Tramrail engineer fill you in on the details.

CLEVELAND TRAMRAIL

Overhead Materials Handling Equipment

CLEVELAND TRAMRAIL DIVISION • THE CLEVELAND CRANE & ENGINEERING CO. • 1354 E. 290 ST. • WICKLIFFE, OHIO

AUTOMATION

catalogs and literature

Latest automation information. For copies use card on page 19.

Multiple-Spindle Drillheads

Thriftmaster Products Corp., Lancaster, Pa.—28 *page catalog*—Catalog 2 describes six types of multiple-spindle drillheads: Fixed center, angular, rotating, double eccentric adjustable, single eccentric adjustable, and universal joint adjustable. In addition it describes automatic reverse tapping attachments (also used for external threading) and tap-or-drill units. Diagrams and photographs illustrate various features of the drillheads.

Circle 461 on Page 19

Fluid Couplings

E. B. Wiggins Oil Tool Co. Inc., 3424 E. Olympic Blvd., Los Angeles 23, Calif.—16 *page booklet*—Data are contained in Catalog GC 2 on a line of fluid, self-sealing, quick-disconnect couplings. This catalog covers seven basic series of these couplings, designated as Inst-O-Matic. It also covers the particular applications of each series. A section of the catalog contains a table of seal recommendations for fluids such as exotic fuels, ethylene oxide, ammonia, nitrogen, and coolants. Pressure drop curves are illustrated.

Circle 462 on Page 19

Numerical Control

Diehl Mfg. Co., Subsidiary, Singer Mfg. Co., Somerville, N. J.—8 *page bulletin*—Brochure contains information on a numerical control system which has a production accuracy of up to ±0.0002 on a 40-inch worktable and features a modular design. Product data and illustrations are provided on all of the system's components. Operational sequences of the system are described from preparation of input data to the completion of the entire work program.

Circle 463 on Page 19

Flange Head Fittings

Fittings & Hose Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio—12 *page booklet* — Flange head fittings, bent tube fittings with 37 degree swivel nuts, and a line of reusable fittings, designated Hoze-lok, are discussed in Catalog 4430. The flange head fittings include straight connectors and 45 and 90 degree elbows as standard stock items. They are provided for five sizes of two-wire-braid high pressure hose, from ¾ through 2 inches inside diameter, and for six sizes of the medium pressure single wire-braid cotton cover hose. The belt tube swivel nut fittings—in 45 and 90 degree elbows and a long 90 degree elbow—are available for high pressure hose from ¼ through 1 inch inside diameter and for medium pressure hose from 5/16 through ⅞ inch inside diameter.

Circle 464 on Page 19

Brushing Tools

American Brush Manufacturers Association, 1900 Arch St., Philadelphia 3, Pa.—16 *page booklet*—Brochure describes a line of brushing tools that are engineered for industrial uses. These uses include such applications as appliance manufacturing, food processing, precision metalworking, sheet and strip metal, structural steel, welding, etc. Photographs illustrate the brushing tools used in these various applications.

Circle 465 on Page 19

Connectors and Accessories

West Instrument Corp., 4363 W. Montrose Ave., Chicago 41, Ill.—6 *page pamphlet*—Bulletin P1 explains and illustrates a line of polarized thermocouple connectors and accessories. It covers in detail plugs, jacks, tube adaptors, cable clamps, panel mounting brackets for plugs or jacks, etched aluminum discs, five terminal jack panels, and multiple circuit strip jack panels. A price list for the various items is included.

Circle 466 on Page 19

Ribbon Blender

Tower Iron Works, 50 Borden St., Providence, R. I.—4 *page pamphlet*—Brochure describes a line of ribbon blenders designed for blending of powders, pastes, and liquids of varying specific gravities. They provide efficient mixing of such materials as pharmaceuticals, plastics, foods, chemicals, synthetics, and cleaners. Balanced ribbons provide internal circulation within the batch, combining self-reversing flow with top-to-bottom turnover.

Circle 467 on Page 19

Temperature Regulators

OPW-Jordan Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio—8 *page bulletin*—Catalog J180-1 contains information on a line of sliding gate and plate temperature regulators. Designed for use with steam, water, air, oil, gas, or chemicals, these regulators control temperatures from 35 to 450 F at pressures up to 250 psig. Self-operated and pilot-operated temperature regulators, and combination temperature/pressure regulators are illustrated by photographs, cut-sections, and line drawings.

Circle 468 on Page 19

Alarm Flowmeters

Instrument Div., Schutte and Koerting Co., Dept. M-S, Cornwells Heights, Bucks County, Pa.—4 *page pamphlet*—Bulletin 18A describes two types of magnetic and electronic instruments for accurately measuring fluid rates of flow and warning of abnormal flow rates. Both types are made to activate a warning light or alarm device, and will start or stop a pump, motor, or control unit. Tables give dimensions, sizes, and capacities. Sectional drawings illustrate components and explain fail-safe operation.

Circle 469 on Page 19

Hydraulic Cylinders

Sheffer Corp., 326 W. Wyoming Ave., Cincinnati 15, Ohio—16 *page booklet*—Line of hydraulic cylinders is covered in Catalog 260. These cylinders are available in bore sizes of 1¼ to 12 inches and with 17 types of mountings. Through the use of two foldouts attached to the front and back covers, mounting accessory, rod, and porting information can be found at a glance when working with

THE MAN & THE DRIVES

FROM WESTINGHOUSE

Mr. Westinghouse and MagnaFlow Drives Bring Simple Solution to Speed Control Problems, Save Money and Space, Too!

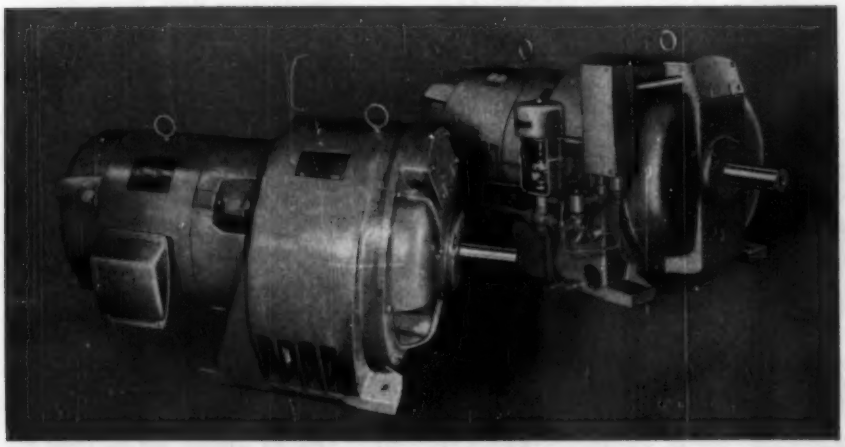
Westinghouse MagnaFlow* electromagnetic drives—air or liquid cooled—provide infinitely adjustable speeds from standstill to top speed with regulation guaranteed at ±2% of top speed over a 17-to-1 speed range (even closer regulation when desired). Control is smooth and stepless.

These compact drives, having a minimum number of parts, are built for rough, trouble-free service. The unique electromagnetic coupling maintains adjustable output speed without the use of pulleys, belts, brushes, commutators, slip rings or rotating windings. A rugged Life-Lin3® "A" motor supplies reliable a-c drive power. No power converting equipment needed—only a small, static exciter and an operator's control station. Initial cost is low; installation—easy and inexpensive.

Your Man from Westinghouse is ready now to help you apply MagnaFlow drives . . . and any other drives you may need. Call him . . . or write for a copy of Westinghouse MagnaFlow Electromagnetic Drives (B-7875), Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. You can be sure . . . if it's Westinghouse.

J-22162

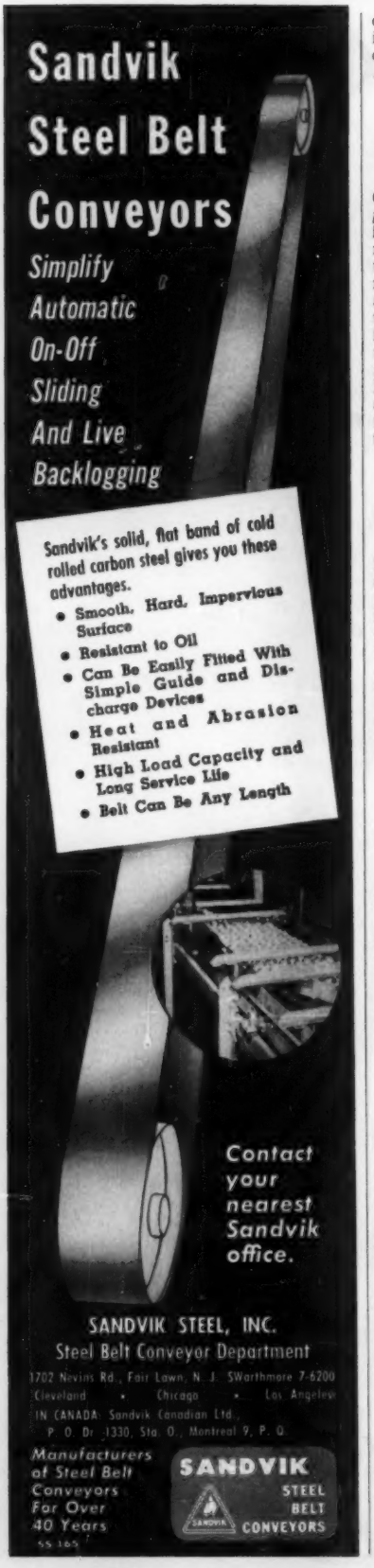
*Trade-Mark



MagnaFlow drives—air cooled (foreground) and liquid cooled—are available in various horsepower ratings for winders, conveyors, fans, pumps, extruders and other machinery in all industries.

Westinghouse

Circle 711 on Page 19


Sandvik
Steel Belt
Conveyors
Simplify
Automatic
On-Off
Sliding
And Live
Backlogging
Sandvik's solid, flat band of cold rolled carbon steel gives you these advantages.
• Smooth, Hard, Impervious Surface
• Resistant to Oil
• Can Be Easily Fitted With Simple Guide and Discharge Devices
• Heat and Abrasion Resistant
• High Load Capacity and Long Service Life
• Belt Can Be Any Length
Contact your nearest Sandvik office.
SANDVIK STEEL, INC.
Steel Belt Conveyor Department
1702 Nevins Rd., Fair Lawn, N. J. SWarthmore 7-6200
Cleveland • Chicago • Los Angeles
IN CANADA: Sandvik Canadian Ltd.,
P. O. Dr. 1330, Sta. O., Montreal 9, P. Q.
Manufacturers of Steel Belt Conveyors For Over 40 Years
SANDVIK
STEEL BELT CONVEYORS
SS 165

Circle 712 on Page 19

data covering any bore size or mounting style. All dimensioning of C4H Series cylinders follows National Fluid Power Association standards.

Circle 470 on Page 19

Subminiature Switches

Unimax Switch Div., W. L. Maxson Corp., Ives Rd., Wallingford, Conn.—16 *page booklet*—Catalog 20-1 contains information on an expanded line of subminiature switches. Listings include such types as high-temperature, sealed, environment-free, and MIL-specification switches as well as phenolic-cased pushbutton, toggle, and integral-actuator types. Information is included on five different terminal styles and a wide variety of multiple-switch/actuator combinations. Data on terminal arrangements, circuit arrangements, and NEMA standard definitions of precision snap-acting switch terms are also included.

Circle 471 on Page 19

Precision Gears

Boston Gear Works, Quincy 71, *Mass.*—26 *page catalog*—Catalog PG 160 provides data on a full selection of fine pitch precision spur gears. Standard sizes range from 48 to 120 diametral pitch—10 to 40 teeth in stainless steel and 42 to 180 teeth in aluminum. These small gears range from 1/10 to 2¼ inches in outside diameter and are used in instruments, meters, and controls, and in precision components for computers, communications apparatus, and similar electromechanical equipment.

Circle 472 on Page 19

Drilling and Tapping Machines

Universal-Automatic Corp., 9545 *Ainslie St., Schiller Park, Ill.*—12 *page booklet*—Brochure contains information relating to a line of automatic machines and systems designed for such secondary operations as high-speed drilling, tapping, and threading. Basic control unit of the machines is explained and illustrated. Data are provided on various types of machines as well as on work holding fixtures and feed mechanisms. Typical parts and production data are described.

Circle 473 on Page 19

Telephone Type Relays

Potter & Brumfield Div., American Machine & Foundry Co., Technical Information Dept., Princeton, Ind.—4 *page pamphlet*—Bulletin 13C148 contains information on a line of telephone type relays. The seven relays discussed include the BS, LS, TS, GS, KS, LT, and MH series. A chart showing all of the electrical and mechanical characteristics of these relays as well as coil data and available enclosures is provided. A nomogram upon which the operating speed of the BS relay can be calculated is described.

Circle 474 on Page 19

Servo Components

Kearfoot Div., General Precision Inc., 1150 *McBride Ave., Little Falls, N. J.*—56 *page handbook*—Handbook, entitled "Technical Information for the Engineer," contains data regarding the construction, performance, application, and testing of servo motors, motor generators, and synchros. It describes in detail the important technical aspects associated with servo components and their uses in systems. Diagrams, charts, outlines, tables, schematics, definitions, and formulas are provided for reference when needed for the designing of high performance servo systems.

Circle 475 on Page 19

Algebraic Compiler

Computer Div., Bendix Corp., 5630 *Arbor Vitae St., Los Angeles* 45, *Calif.*—32 *page handbook*—Manual contains data regarding an algebraic compiler used to program a general-purpose G-15 digital computer in universal mathematical language. It describes the language, designated ALGOL, for the computer and sets forth procedures for the representation of numerical data and control statements. Step-by-step examples illustrate principles and operational characteristics of the device.

Circle 476 on Page 19

Hydraulic Valves

Sarasota Precision Products Inc., 5757 *McIntosh Rd., Sarasota, Fla.*—*data sheets*—Four one-page bulletins contain data covering spring centered, spring offset, and detent hydraulic valves, designed for use in small, high pressure circuits where flow is 3 gpm or less and operating pressure is 0-2000 psi. These 4-way hydraulic valves provide 11 flow patterns. Flow-pressure characteristics, dimensions, and approved JIC symbols for the units are provided.

Circle 477 on Page 19

Production Rate Recorder

R. B. Annis Co., 1101 *N. Delaware St., Indianapolis* 2, *Ind.*—1 *page pamphlet*—Bulletin PRR-60 describes a portable instrument for analyzing the production rates of automatic machines. This production rate recorder plots by strip chart a complete log of production rate information for any machine. It automatically integrates production data, constantly comparing actual rate with a predetermined standard reference rate. Deviations from standard are shown in percentage on the chart. The unit is a companion instrument to a time-speed recorder and operates on 115 v, 60 cycles.

Circle 478 on Page 19

Electric Motors

Doerr Electric Corp., 100 *N. Fourth Ave., Cedarburg, Wis.*—14 *page booklet*—Data for selecting and specifying a line of fractional and integral horsepower motors are contained in Bulletin 150. The catalog gives construction and dimensional details for the units and describes many motor modifications which are available. Special designs of varied types are illustrated.

Circle 479 on Page 19

Aluminum Melting Furnaces

Hevi-Duty Electric Co., Milwaukee 1, *Wis.*—8 *page bulletin*—Line of reverberatory melting furnaces for aluminum is described in Bulletin 5910. This line fea-

tures three furnaces designed for use in sand casting, die casting, and permanent mold plants. Available in gas, oil, or combination fuel-fired models, furnaces feature direct firing which provides maximum melting under controlled combustion conditions. These furnaces are capable of melting 150 to 3000 lbs of aluminum per hour with bath capacities ranging from 650 to 5000 lbs of molten aluminum. All furnaces include burner equipment, gas pilots, firebrick or silicon carbide lining, and a centrifugal blower.

Circle 480 on Page 19

Data Handling System

Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.—4 page pamphlet—Data Sheet N-07(2) describes a 600-channel sequential data handling system in use to monitor the bearing, boiler tube, and condensate temperatures of a 290-megawatt boiler turbine-generator unit. Operation of the system is explained by means of a schematic diagram. Details are provided on modes of operation, time per channel, visual displays, and channel switching.

Circle 481 on Page 19

Chemical Processing Equipment

Fuller Co., Catasauqua, Pa.—12 page booklet—Bulletin G-3D describes a line of equipment for the chemical process industries. Discussed are applications and performance characteristics for such devices as pneumatic conveyors, fluidizing conveyors, rotary compressors, vacuum pumps, and Sutorbilt positive displacement blowers and gas pumps. Photographs and drawings illustrate construction details of the various items.

Circle 482 on Page 19

Bimetal Thermostats

Stevens Mfg. Co. Inc., P. O. Box 1007, Mansfield, Ohio—4 page pamphlet—Bulletin 8400 covers a line of bimetal thermostats. Each major thermostat group is pictured. Data for both semienclosed and hermetically sealed styles are given. Applications for the various types of thermostats include appliances, electronic and avionic devices, and apparatus. A chart for converting Centigrade and Fahrenheit temperature scales is also included.

Circle 483 on Page 19

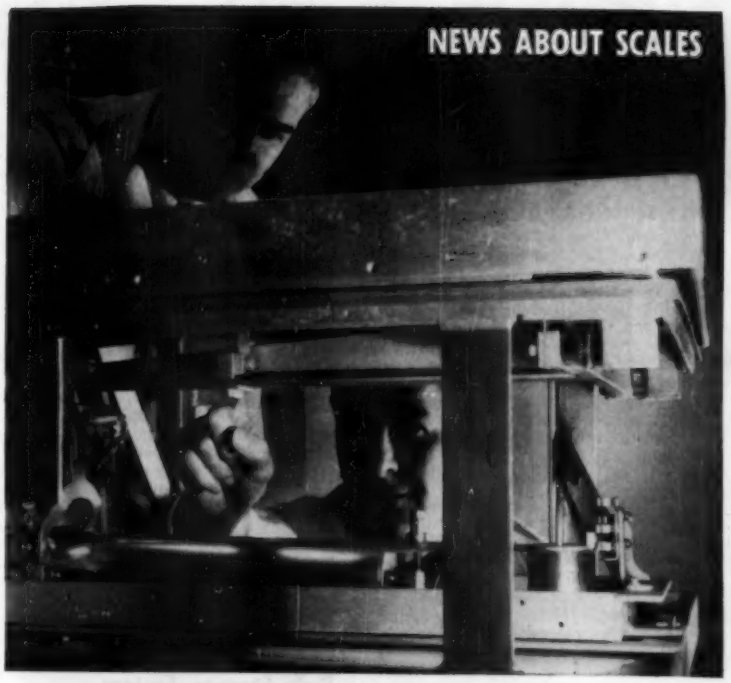
Contactors and Starters

General Electric Co., Schenectady 5, N. Y.—20 page catalog—Magnetic contactors and starters in NEMA sizes 0-5 are covered by Catalog GEA-7020. Details are provided on combination starters, reversing two-speed controllers, and available modification kits. Application, installation, and maintenance information along with a discussion of construction details, including photographs and descriptions of subassemblies, are provided.

Circle 484 on Page 19

Recording Spectrophotometer

Baird-Atomic Inc., Infrared Sales, 33 University Rd., Cambridge 38, Mass.—2 page pamphlet—Data sheet 460 explains and illustrates an infrared double-beam recording spectrophotometer with auto-



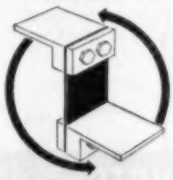
How do they build unvarying accuracy into this remarkable new kind of weighing instrument?

For 7,000 years men have employed the multi-part pivot balance to compare weights. As the parts of their pivot joints wore, the problem of retaining accuracy became more and more acute. Then in 1956 the United States issued a patent for a "Thayer Flexure Plate" Leverage System. A team of engineers and businessmen, aware of industrys great cumulative loss of materials in weighing operations, had devised a revolutionary new scale. Knife-edge pivots that progressively wear and change were replaced by Thayer Flexure Plates that move only .001", yet accurately reflect the minutest changes in weight. This *firmly joined* lever withstands shocks and vibrations indefinitely. Dirt and dust are no longer a problem.

Thayer guarantees this leverage system accurate for the life of the scale.

How Can It Save You Money Year After Year?

Working in conjunction with straight electrical controls, it forms the most reliable, low maintenance system ever devised to control processing or materials handling *by weight*. Literature on its application to filling, batching and checkweighing operations is available on request.



THAYER SCALE

AUTOWEIGHTION SYSTEMS FOR FILLING BATCHING AND CHECKWEIGHING

THAYER SCALE CORP. THAYER PARK PEMBROKE, MASS.

A Subsidiary of SUNDSTRAND CORPORATION

Circle 713 on Page 19

matic scan control and accelerated scan program for research and control. The unit is available in two models and has a continuously accelerated scan speed of 2-16 microns in 4 minutes. Constant scan speed models are also available. Accessories include 20-meter gas cell, ultramicro liquid cells, and a microbeam condensing system.

Circle 485 on Page 19

Refrigerated Air Dryer

Hankison Corp., College and Pike, Canonsburg, Pa.—2 page pamphlet—Bulletin 9100 contains data on a refrigerated air dryer, designated F-30 Refrigifilter. This unit is designed to give medium capacity pneumatic systems microclean, dehydrated, and oil-free compressed air. It protects the systems from destructive moisture, oil vapors, and other contaminants. The unit has a rated capacity of 30 scfm and combines the functions of a refrigerated condenser, separator, filter, and trap.

Circle 486 on Page 19

Inclinable Power Presses

Cleveland Punch & Shear Works Co., 3917 St. Clair Ave., Cleveland 14, Ohio.—8 page bulletin—Welded steel line of inclinable power presses is described in Folder OBI-3'60. These presses are of a 75 to 200 ton capacity. Photographs illustrate various press components as well as the presses themselves. A selection chart is included that shows both standard and extra features available.

Circle 487 on Page 19

Hydraulic Equipment

John S. Barnes Corp., 315 S. Madison St., Rockford, Ill.—8 page bulletin—Catalog EJS contains data regarding a line of hydraulic equipment for both machine tool and industrial applications. The machine tool hydraulic line includes such units as vane-type pumps, directional control valves, and standard fluid power devices. The industrial hydraulic line contains items such as constant flow rotary gear pumps, pump and motor units, flow dividers, and automotive power units. Photographs illustrate all models. The catalog includes a multitude of application recommendations.

Circle 488 on Page 19

Electrically Controlled Inductors

Trak Electronics Co., 49 Danbury Rd., Wilton, Conn.—2 four-page pamphlets—"Designing for Stability," Parts 1 and 2, was written to assist design engineers in the use of electrically controllable inductors in applications in which the effects of temperature change and hysteresis must be minimized. Part 1 describes the effects of hysteresis and temperature changes and various open loop methods for minimizing these effects. Part 2 deals with specific closed loop and bellweather stabilization circuits.

Circle 489 on Page 19

Bulk Storage System

Harvestore Products Div., A. O. Smith Corp., Kankakee, Ill.—16 page booklet—Bulletin MU-107 contains data on a Permaglas bulk storage unit with glass-fused-to-steel construction on the inside and out. This storage unit features a mechanical sweep-arm bottom unloader which makes possible completely automatic systems for storing and conveying bulk materials into process. Details are provided on a Permaglas cone bottom, a modular storage bin, and a bulk storage structure. Schematic diagrams illustrate typical installations of the units.

Circle 490 on Page 19

Magnetic Pickups

Electro Products Laboratories Inc., 4501 N. Ravenswood Ave., Chicago 40, Ill.—4 page pamphlet—Bulletin CMP-50 covers a line of magnetic pickups that generate voltage and power without the aid of power supplies and can be used for extremely accurate conversion of mechanical motion to electrical impulses. A selection guide chart simplifies pickup selection by describing the devices in terms of physical size, electrical output, temperature range, and types of mating connectors required. Diagrams illustrate use of the pickups for counting revolutions, as an input for a tachometer, for measuring speed, and for reversing direction of motion.

Circle 491 on Page 19

Lubrication Systems

Bijur Lubricating Corp., Rochelle Park, N. J.—4 page pamphlet—Bulletin CL presents details on three types of automatic lubricating systems, designated Circulube. These systems provide positive control of oil feed and circulation rates. The bulletin includes both photographs and engineering drawings to illustrate product data and specifications. Copy material describes the components as well as a pressure signal switch which makes it impossible for a machine to be operated unless it has adequate lubrication.

Circle 492 on Page 19

Numerical Positioning Controls

Electronics Div., Rheem Mfg. Co., 5200 W. 104th St., Los Angeles 45, Calif.—8 page bulletin—This booklet contains data on a line of numerical positioning controls for machine tools. These controls are applicable to such machines as turret drills, mills, and a large variety of special tools. A control lock diagram illustrates programming tape, electronic controls, and machine elements utilized in a typical control application. Photographs and dimensions are provided for both a four-axis and a two-axis console.

Circle 493 on Page 19

Pipe Fittings

Grayloc Sales Div., Gray Tool Co., P. O. Box 2291, Houston 1, Tex.—44 page catalog—Data are contained in this catalog on a line of pipe connections and accessories designed on a new seal principle which eliminates connection leakage at pressures to 40,000 psi and permits design for high resistance to thermal shock and vibration. The seal ring may be employed with a two-bolt clamp, union, or flange. Featured in the catalog is a ten-page table of allowable working pressures for pipe and connections from 1 to 30 inches and at temperatures from 100 to 1500 F. All types and ratings of clamps, collar-type unions, flanges, vessel

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nozzles, closures, and bleeder valves are covered. Products with related applications such as bimetallic pipe and fittings are also covered.

Circle 494 on Page 19

Language Translator

Hermes Electronics Co., 75 Cambridge Parkway, Cambridge 42, Mass.—4 page pamphlet—Bulletin describes various types and techniques of code conversion and the relative merits of different numerical codes which may be employed by design engineers. Also included is a discussion on the theory of numerical codes. Details are provided on a line of translators which can be used to convert digital input data into usable output form.

Circle 495 on Page 19

Voltage Regulators

Raytheon Co., Power Supply and Voltage Regulator Operations, Keeler Ave., South Norwalk, Conn.—10 page bulletin—Catalog 4-265 provides information on more than 2000 magnetic voltage regulators. These units are available in a variety of voltage and power ratings for ac line regulation lamp and vacuum-tube filament supplies, and dc power supply applications. A large fold-out chart simplifies selection of regulators with desired electrical and physical characteristics.

Circle 496 on Page 19

Tachometer Indicators

Madison Electric Products Inc., Madison, Ohio—4 page pamphlet—Nine tachometer indicators and six electric generators for tachometer service are described in detail in this catalog. Also included is information covering the use of this type of equipment in connection with variable speed applications. Details are given on a fan style, long scale, switchboard type indicator designed for use where speed observations of equipment are of a critical nature.

Circle 497 on Page 19

Dry Magnetic Particle Clutch

Electric Products Div., Vickers Inc., St. Louis 3, Mo.—4 page pamphlet—Data on a dry magnetic particle clutch are contained in Bulletin EPD 6105-5. Designated as Magnaclutch, this unit has a torque of 10 lb-ft. Details are given on the construction and operational features of the clutch as well as on its dimensions and specifications, performance curves on heat dissipation, and torque transmission.

Circle 498 on Page 19

General Purpose Relay

Union Switch & Signal Div., Westinghouse Air Brake Co., Advertising Dept., Pittsburgh 18 Pa.—4 page pamphlet—Brochure describes a two-pole, double-throw general purpose crystal case relay. Unit features a torsion wire armature suspension system which is designed to meet a high level of vibration immunity. Coil voltage of the relay is 26.5 volts dc nominal with 660-ohm coil. Contact resistance is 0.05 ohm maximum at rated load, and temperature rating, −65 to +125 C.

Circle 499 on Page 19

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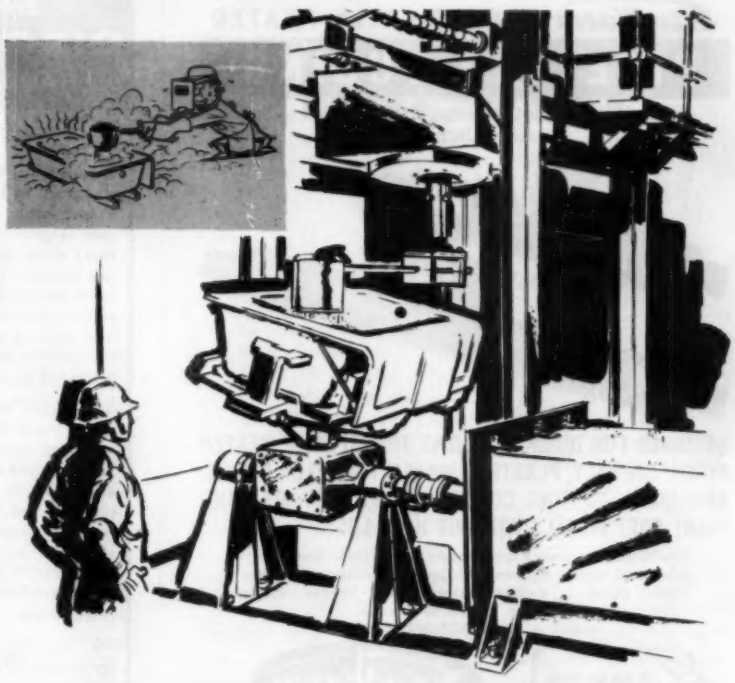

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Circle 715 on Page 19

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Circle 716 on Page 19

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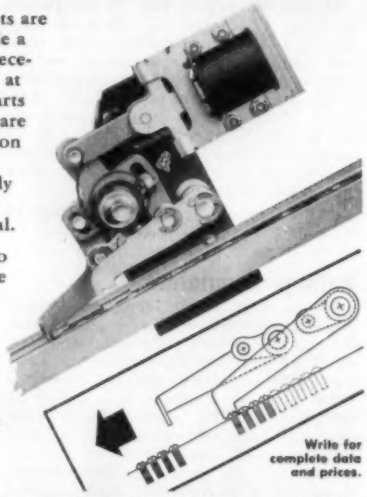

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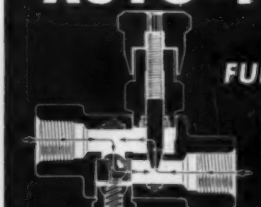

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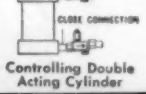

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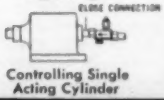

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Circle 719 on Page 19

AUTOMATION abstracts

ANALYZING PNEUMATIC CIRCUIT FLOWS

By G. Riske
Senior Engineer
Hannifin Co., Div.,
Parker-Hannifin Corp.
Des Plaines, Ill.

INTENT of flow analysis in pneumatic circuits is not to oversize a system purposely, but rather it is to check against unintentional undersizing. It is also intended that the method discussed be applied directly to the pneumatic system on the machine or anywhere in the plant. For this analysis, pressure gage taps may be made at pipe tees inserted in the lines for this purpose.

The most difficult steps in any analysis are concerned with getting started. With pneumatic circuits, this is more often the rule than the exception. Basically, once the flow factors of the system sections have been determined, the relationship between the pressure losses and air flow rate can be evaluated. The difficult phase concerns determining the flow factors.

Although capacity coefficients are commonly used to rate industrial fluid components, I suggest the use of flow factors in pneumatic circuit analysis because it represents a direct all-around means for getting the job done. The National Bureau of Standards originally recommended the use of flow factors to rate pneumatic valves and other components. The concept of flow factors stems from the classically derived equations which were frequently applied, early this century, to the solutions of gas and air flow problems through pipes.

Numerically, the flow factor of a pneumatic component may be defined as the maximum air flow rate that can be put through it for each pound per square inch of absolute supply pressure. For example, a valve with a flow factor equal to one would permit a maximum air throughput of 95 standard cubic feet per minute with an absolute supply pressure of 95 psi.

The basic flow factor equation is:

$$Q_o = 1.153\, F_o \sqrt{(P_1)^2 - (P_2)^2} \quad \ldots\ldots (1)$$

or

$$Q_c = 1.153\, F_c \sqrt{(P_1)^2 - (P_2)^2} \quad \ldots\ldots (2)$$

and, for other temperatures and specific gravities, the flow factor F_o can be converted to F_c as follows:

$$F_c \sqrt{G_c\, T_c} = F_o \sqrt{G_o\, T_o} \quad \ldots\ldots (3)$$

where

F_c = Flow factor at conditions other than standard.
F_o = Flow factor at standard conditions (68 F and 14.7 psia.)
G_c = Specific gravity of gas if different from air.
G_o = Specific gravity of air = 1
Q_c = Air flow rate, cubic feet per minute at conditions other than standard.
Q_o = Air flow rate, standard cubic feet per minute (68 F and 14.7 psia).
T_c = Temperature at conditions other than standard (460 + t degrees F)
T_o = Temperature at standard conditions (460 + 68 F = 528 R)

Note: When $P_2 \leqq \frac{1}{2} P_1$, use $F = Q_{max}/P_1$ and use $P_2 = \frac{1}{2} P_1$

Equations 1 and 2 are variations of that proposed by the National Bureau of Standards for rating pneumatic valves. Equation 3 includes the correction factors for specific gravity and temperature.

The National Bureau of Standards' suggestion for determining the total flow factor of a series of components has been reworked and simplified to a graphical process whereby the flow factors may be related to lengths of straight pipe or tubing of any internal diameter. In the process of determining the system section flow factors, all component flow capacities must be expressed in terms of equivalent feet of straight pipe of a common internal diameter. After this is done, it is simply a matter of totaling these lengths and converting this total length into the section flow factor.

There are a variety of methods used to express the fluid flow capacities of pneumatic system components. It is necessary to convert these expressions to flow factors.

Valve manufacturers often rate their products with flow capacities called capacity coefficients, C_v. A close approximation in converting is to assume that the C_v rating is numerically twice that of the equivalent as a flow factor. For example, a C_v rating of three would be equivalent to a flow factor rating of one and one-half.

For conversion of other air and gas flow coefficients into flow factors it is suggested that the flow coefficients be used to solve for the upstream and downstream pressures and air flow rates closest to the estimated use. This data can be converted to the flow factor.

If the flow capacity data of any unrated components is not available, try contacting the manufacturer for it. However, if the component is on hand, it may be more convenient to do the testing or have it tested. If these alternatives are not available, calculate the expected flow factor of the component from the physical dimensions of the passage contours.

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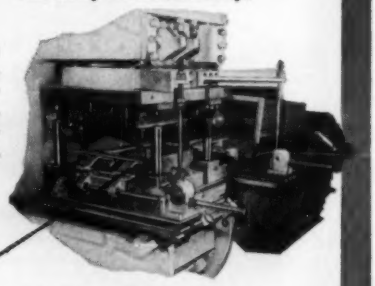

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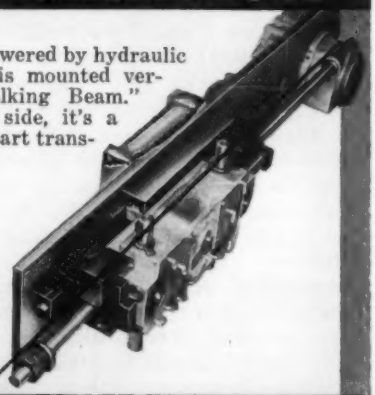

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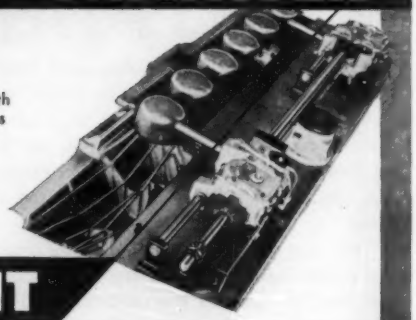

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components involves the use of pressure gages both upstream and downstream from the unrated unit, as well as another pair of gages both upstream and downstream from a rated section of the system that handles the same volume of air during the cycle. This method involves the use of the following equation:

$$F_a = F_b \sqrt{\frac{(P_3)^2 - (P_4)^2}{(P_1)^2 - (P_2)^2}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where

F_a = Flow factor of unrated component.
F_b = Flow factor of rated component.
P_1 = Upstream Pressure, psia, unrated component.
P_2 = Downstream Pressure, psia, unrated component.
P_3 = Upstream Pressure, psia, rated component.
P_4 = Downstream pressure, psia, rated component.

The rated section may be no more than pipes and fittings that provide a pressure loss of five to ten per cent of the upstream pressure at the measured flow conditions. This method ignores the direct measurement of the air flow rate although it can be determined with Equation 1 or 2 using the pressure gage readings and the flow factor of the rated section.

The direct measurement of air flow rate may be desirable even with a makeshift device of reasonable accuracy. Such a device can be made with only pipes, fittings, and pressure gages. Be sure to use pipe, tees, and nipples of the same nominal pipe diameter and schedule. Also, the pipe unions should be any convenient size equal to or larger than the nipples. A differential pressure gage is preferred because the pressure loss can be read directly. Also, locate this pipe arrangement upstream from the pneumatic system so that the normal operating cycle is not affected by the additional pressure loss.

While this method of flow measurement is not recommended to replace any of the orthodox flow meters, it will prove invaluable when no standard flow meter is available. If maximum accuracy is desired, calculate the flow factor of the pipe set from the actual internal dimensions of the pipe and tees, or determine the flow factor with a pressure loss and air flow rate test. Also, remove the cutting burrs at the entrance and exit of the nipples and the rated section of pipe. With reliable pressure gages, this method should give results within ten per cent of the actual flow rates.

Generally, the combining of the flow factors by the National Bureau of Standards method is accomplished without consideration of the actual order of the components in the system. However, this method gives results which are representative of the highest stagnation losses due to the least favorable sequence of the components in series. Therefore, any other arrangement of the same components will demonstrate actual flow factors up to ten per cent greater than calculated.

Theoretically, the optimum arrangement of components in series occurs when the flow factors of the successive components in series are related to the flow factor of the first component by the expression $2^{(n-1)}\ F_a$, where F_a is the flow factor of the upstream component and n is the component number counting from the upstream unit as number one. Therefore, the successive component flow factors would be F_a, $2\ F_a$, $4\ F_a$, $8\ F_a$, ... , $2^{(n-1)}\ F_a$ as the optimum arrangement.

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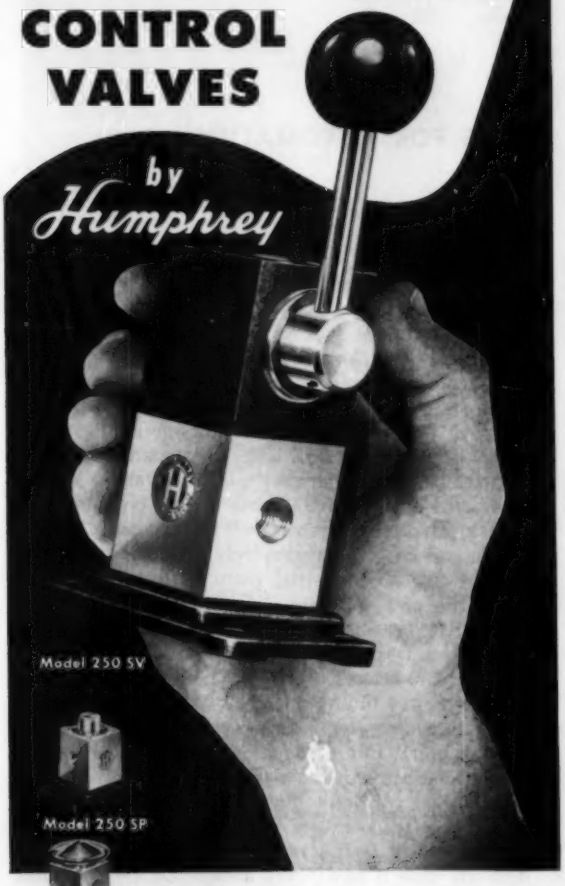

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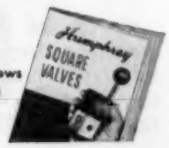
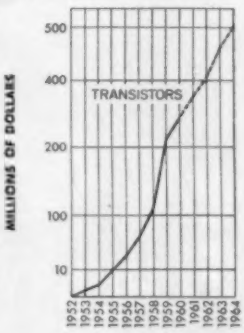


Circle 742 on Page 19

Computer Analysts

New Openings in one of General Electric's fastest growing technical areas

The Semiconductor Products Department of the General Electric Company has new openings for qualified personnel experienced in computer applications. These are permanent, career opportunities involving the design of computer data systems for advancing semiconductor technology—the fastest growing area in the electronics industry (see graph, right).



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Circle 721 on Page 19

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The above arrangement suggests that the otherwise optimum succession of components in series occurs when the components are situated with progressively increasing flow factors beginning with the upstream unit having the smallest flow factor and working in the downstream direction.

From a paper entitled "Analyzing Pneumatic Circuits —It's an Art," presented at 16th annual meeting of the National Conference on Industrial Hydraulics, Chicago, October, 1960.

SKILLS FOR AUTOMATION

By F. J. LEE
Manager of Training Services
Raytheon Co.
Waltham, Mass.

WE ARE IN, and have been in for some time, an age of technological innovation. Such innovation breeds on itself, so to speak, and proceeds at an ever increasing rate. It was a long time between rayon and Nylon. It was nowhere near as long between Nylon and Dacron. It is not at all unusual nowadays for companies to announce matter-of-factly that thirty or forty or fifty per cent of their volume is in products unheard of ten years ago. These companies have accepted the condition that they must innovate to survive.

Competition is a driving force in our economy, and we have all profited from it. The European nations and the Far East are aggressively competing in world markets—with an industrial plant built or largely rebuilt in the past 15 years. Without even considering the U.S.S.R or South America, foreign competition will give us a run for our money such as we have never known before.

These are two of the major reasons, then, for turning to automation—foreign competition and technological innovation. But automation itself is technical innovation, and if we don't pre-plan our advent into automation, if we don't build in the control mechanisms and the escape valves, we may cripple our productive capacity by trying to increase it too rapidly.

And the time is now. We are not on the threshold of the Age of Automation—we have entered it. From almost nothing in 1945, the automation equipment industry has grown to a $7 billion business.

There is today, and probably will continue to be for some time, a good deal of debate about the long-term effects of automation. However, there seems to be little debate about the characteristics and the skills of the workforce we need to make automation effective. To supply the workforce with the variety and complexity of skills and abilities it will take to make automation pay off, we are going to have to cultivate our human resources as never before.

Skill Shifts

Conceptual skills will be most in demand. True automation replaces discrete unit operations with an integrated process, and will require an awareness throughout the workforce of problems of a total process, rather than of specific units of equipment. In the

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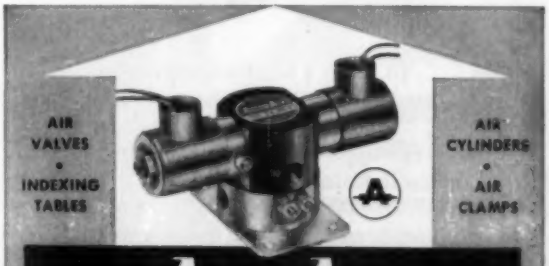

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past, the major contribution of the workforce was in manual and bodily activity. Today, it is mainly perceptual. This is because we are extensively mechanized but not highly automated. In servicing highly automated operations, conceptual skills will be a prerequisite.

The cost of downtime in automated production operations is prohibitive. An operator will very probably be required to diagnose malfunctions, select an appropriate course of action, and apply it. In a very real sense, he must become a supervisor.

Our craft and technician groups are not only failing to keep pace with industrial expansion, they are actually shrinking. And in these groups, more general skills will be needed. Maintenance electricians will need to know a good deal of electronics; pipe-fitters will need hydraulics training, etc. They too will have to assume more supervisory responsibilities.

The skills of the office and clerical workforce will be refined by electronic data processing—office automation. Here again, more complex skills are in demand. Electronic data processing requires programmers, key punch operators, verifiers, etc. Paradoxically, we may have to give handwriting training. Recently an error caused by a poorly written instruction sent 75,000 invoices streaming through an incorrect program.

"First-line supervisors" will be relieved of a large share of the paperwork and recordkeeping responsibilities they have now. This will probably be a mixed blessing; offsetting this relief will be a much heavier demand on their conceptual skills.

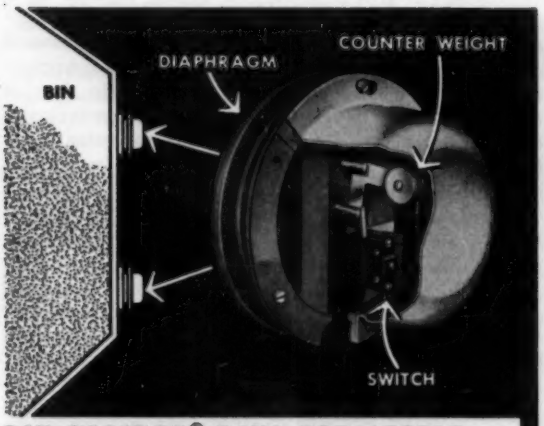
Automation will have marked effects on middle management. Data processing will reduce unknowns and ease decision making. However, there will be more decisions to make, and these will be centralized. There will be more supervisors, but levels of supervision will be reduced in number. Each manager will supervise fewer subordinates, but each of those will be very important, and the manager will need human relations training as well as technical know-how.

Line and staff relationships will tend to merge for those reasons and because highly technical intervention will be instantly necessary if costly downtime is to be controlled. The concepts of systems design, systems operation, and systems maintenance will further blend many of today's functional distinctions.

Management at top level is going to have to "tighten up" to develop truly executive skills. Policy makers will be increasingly called on for more leadership and less chairmanship. I think the concept of the "task force" will gain ground, for the very simple and economically justifiable reason that members of a task force are selected on the basis of their qualifications to tackle a specific problem, not on the basis of the level of the positions they hold.

I haven't said very much about machinery because I don't think it is the critical problem. It's quite possible that we'll have too much, too soon. Our critical area of need is in the development and the use of our human resources, at all levels of the workforce.

We need a skilled workforce to reap the benefits of automation. It will be sheer folly to delude ourselves that the necessary capabilities will develop spontaneously. People do learn by experience. Un-



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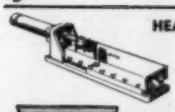
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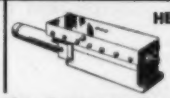
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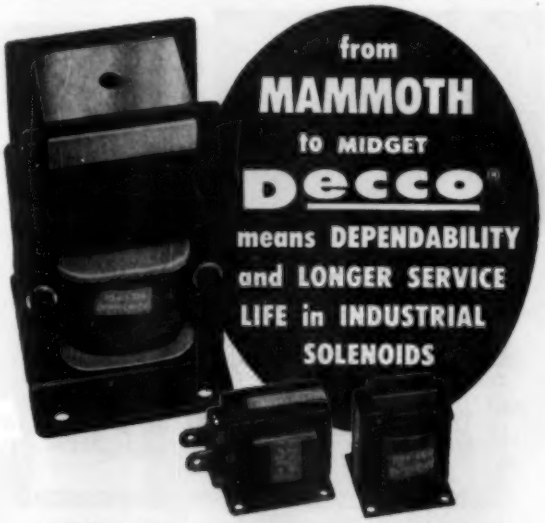

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fortunately, it is a characteristic of the human being that what he learns by experience comes slowly, frequently turns out to be ineffective, is often wasteful of time and material, and sometimes is downright dangerous to himself and to others. To do the job that needs to be done we are going to have to assess the needs, develop the objectives, program the training, evaluate the results, and feed back the evaluations into the training process.

In the widest area of responsibility, we should do at least three things immediately. First, we should step up formation, on a local level, of industry-labor-community task forces to assess needs. Examples of such projects are the Bridgeport area study; the Waterville, Maine, town survey; and the Greater Lawrence manpower committee.

Second, we should organize on a national level a Committee on Human Resources. Such a committee would serve to promote formation of local task forces, counsel them, integrate their findings, and provide guidance in implementing resultant programs.

Third, we should step up the pace and number of programs in vocational and technical education and training now offered. Government has already contributed here, and we have enabling legislation popularly known as the National Defense Education Act. By intelligent, aggressive promotion, we should exploit this avenue to its fullest extent.

Narrowing down the area of responsibility, we must intensify our apprentice training efforts. Present programs give us a base, and there are encouraging signs that both labor and industry are recognizing the needs. But, the Federal Bureau of Apprenticeship calculates that U. S. industry is training only one apprentice for every fifty skilled workers, far less than even the replacement rate.

In an area of responsibility that industry can share with no one, it must critically evaluate the skills of its supervisory force, managers, professional personnel, and top executives. My own belief is that industry will have to accept, and use with maximum effect, a concept that might best be described as "organizational systems engineering."

The industrial organization is a system of working relationships between and among individuals and groups. We must realize that human motivation is complex, and frequently non-rational. We are going to have to take a much closer look at the specifications for human components. It may turn out to be an excruciating reappraisal—a good many comfortable and cherished myths and fables may fall by the wayside.

Only top management can make the decisions that will bring the social science skills and knowledge into intelligent, effective use in industry. Those decisions top management must make, and give the social scientist his place on the team of organizational systems engineers. Then we will be equipped to develop the workforce that can meet the challenge of automation.

From a talk entitled "Responsibilities of Industry, Labor, the Government and the Public in Supplying Skills for Automation" presented at the Conference on Automation, called by the Governor of Massachusetts, Cambridge, Mass., June 1960.

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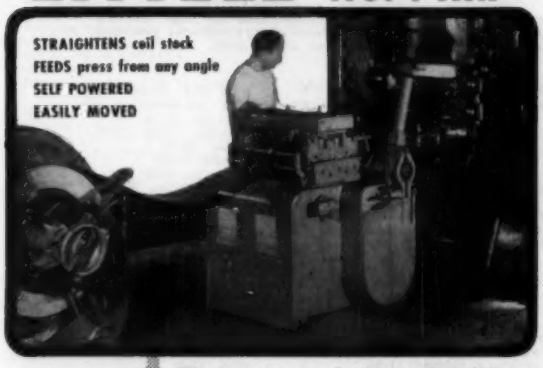

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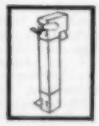

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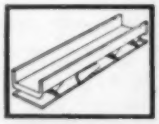

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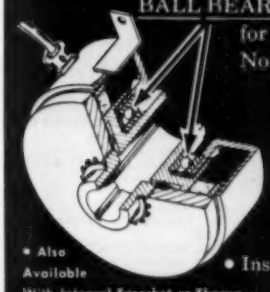

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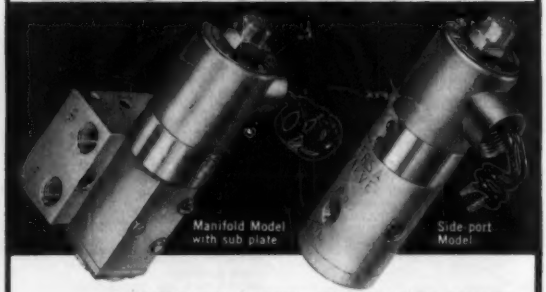

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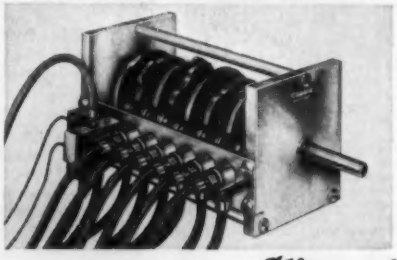

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DICTIONARY OF AUTOMATIC CONTROL

By Robert J. Bibbero, chief engineer, applied science, Bulova Research & Development Laboratories Inc.; 282 pages, 5 by 7¼ inches, published by Reinhold Publishing Corp., New York; available from AUTOMATION; $6.00.

In addition to defining terms pertinent to the field of automatic control, the author has in most instances included a condensed discussion of each term. Usefulness of this book is enhanced by an index that classifies the various terms into major topic areas of: Control theory and basic concepts, computers and data processing, industrial machine and process control, aircraft-missile control and telemetering, and control components and design factors.

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This is a second edition of a well-received earlier book. It is aimed at satisfying the practical interest of those concerned with the basic principles and application of measuring devices. Typical chapter subjects are: Adopting meter movements for current and voltage measurements, power measurement and wattmeters, multi-range instruments and volt-ohm milliammeters, specialized measurements, and advanced meter features.

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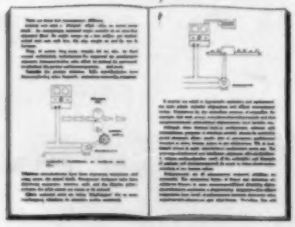

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Easily-installed Mek standard load controls make low-cost automation possible by sensing the telltale deviations in motor input current that indicate end-of-cycle, end-of-material — changes in speed, pressure, or torque. Responding instantly to predetermined degrees of overload or underload, the Mek control automatically initiates the desired reaction: *stop, start, reverse, index, trip, signal, compensate, change speed, or recycle.* You can safely increase machine load and production flow without risk of exceeding specified limits.

Send today for your free book of actual plant applications. Learn how low-cost Mek load controls are automating and regulating production machinery, conveyors, and packaging systems in metalworking, food processing, textile, papermaking, and other industries.

MEK
Machinery Electrification, Inc.
62 Hudson St., Northboro, Mass.

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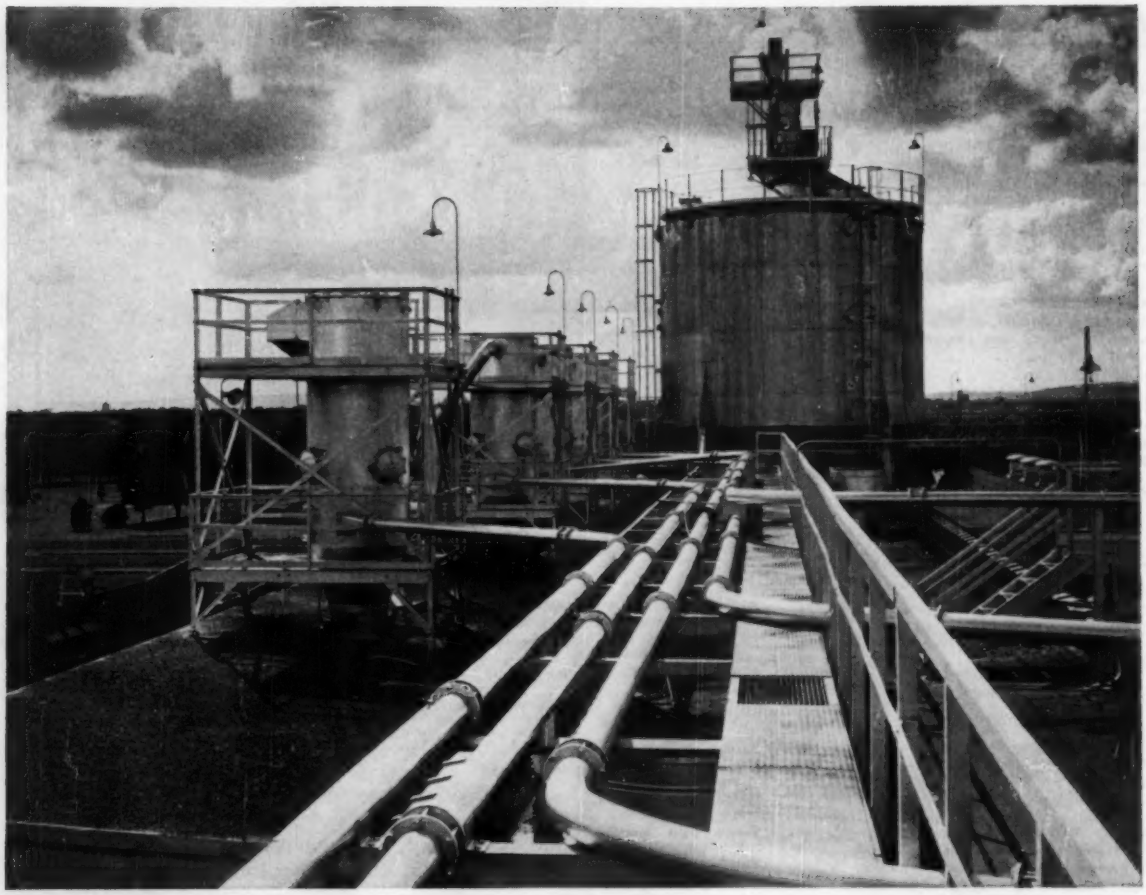

FULLER PNEUMATIC CONVEYING SYSTEMS INCREASE PRODUCTION, CUT CONTAMINATION FOR GOODYEAR

Recent installation of specially engineered Fuller Airveyor® pneumatic conveying systems to handle pelletized rubber has helped Goodyear Tire and Rubber Company increase production. These systems are the latest Fuller design resulting from over 15 years experience in pneumatic conveying of rubber pellets. These completely enclosed automatic systems virtually eliminate contamination problems and greatly reduce the chance of loss due to spoilage.

Automated handling of crude rubber with Fuller Pneumatic Conveying Systems, in place of conventional rubber slab sheeting on a mill, is the key. One Airveyor system conveys the pelletized rubber from the pelletizer to a weigh station, a distance of 500 feet. Four more systems operate from the sink dump scales to inlet spouts of the finish-run Banburys.

All of these Airveyor pneumatic conveyors are of the vacuum type, employing positive pressure exhausters for air supply. Each conveying system is equipped with its own individual bag-type filter, automatic in operation, which provides for 100% visible dust retention. Exhausters and filters are located on the roof. A control panel permits manual or automatic operation of the entire handling system.

If you are handling dry, bulk, granular materials, a Fuller Conveying System application-engineered to your process can be equally advantageous. Look to Fuller, whose range of products coupled with experienced know-how offers you the best *single source* for solving pneumatic materials handling problems. Just call or write Fuller today outlining your problem—no obligation, of course. A-289 1954

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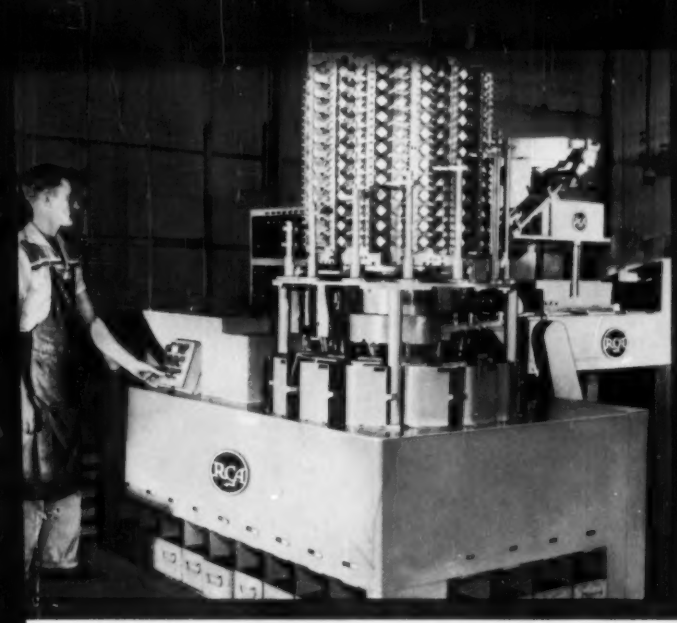

GAGING—Roller Bearing Inspection Machine gages O.D. and segregates roller bearings into 8 acceptable categories in increments of .0001", as well as over and under size. Capable of rates in excess of 15,000 parts per hour.

FINAL INSPECTION—Piston Checking Machine inspects up to 2600 4" to 4⅛" diameter pistons per hour fed at random. Inspects O.D., I.D., length, taper, true roundness. Segregates into 12 acceptable classifications, plus over and under, and automatically counts and totalizes.

RCA electronic inspection systems

First Choice for Reliability, Accuracy, High-Speed Operation

To meet today's critical needs for reliability, many leading companies are switching from statistical quality control to RCA's 100% automatic inspection systems. Illustrated are only a few of the "proved in use" gaging, testing and inspection systems available. With these high-speed systems, increases in production rates up to 800% over manual inspection have been reported, with superior reliability and accuracy.

Whatever your requirements . . . a fully integrated automation system, or simple mechanization of individual operations, RCA Industrial Controls offers the most versatile range of such equipment available from any source.

For details, contact your nearest representative, or write to RCA Industrial Controls, 12611 Arnold Avenue, Detroit 39, Michigan.

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RADIO CORPORATION OF AMERICA

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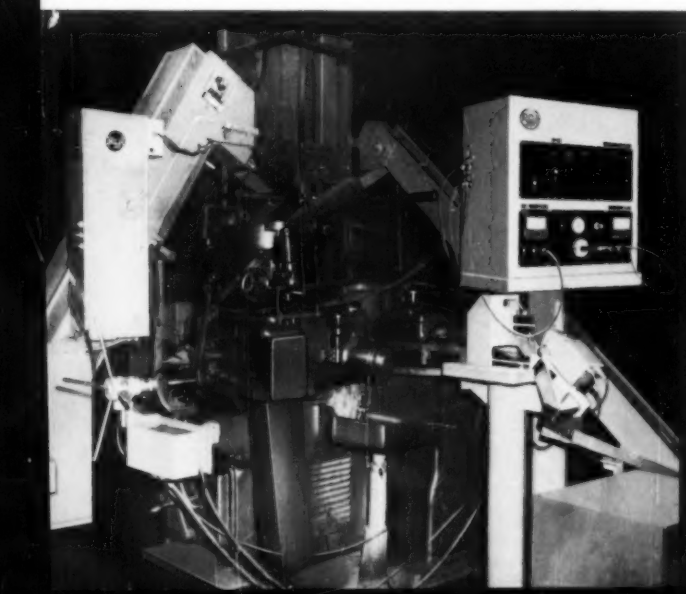
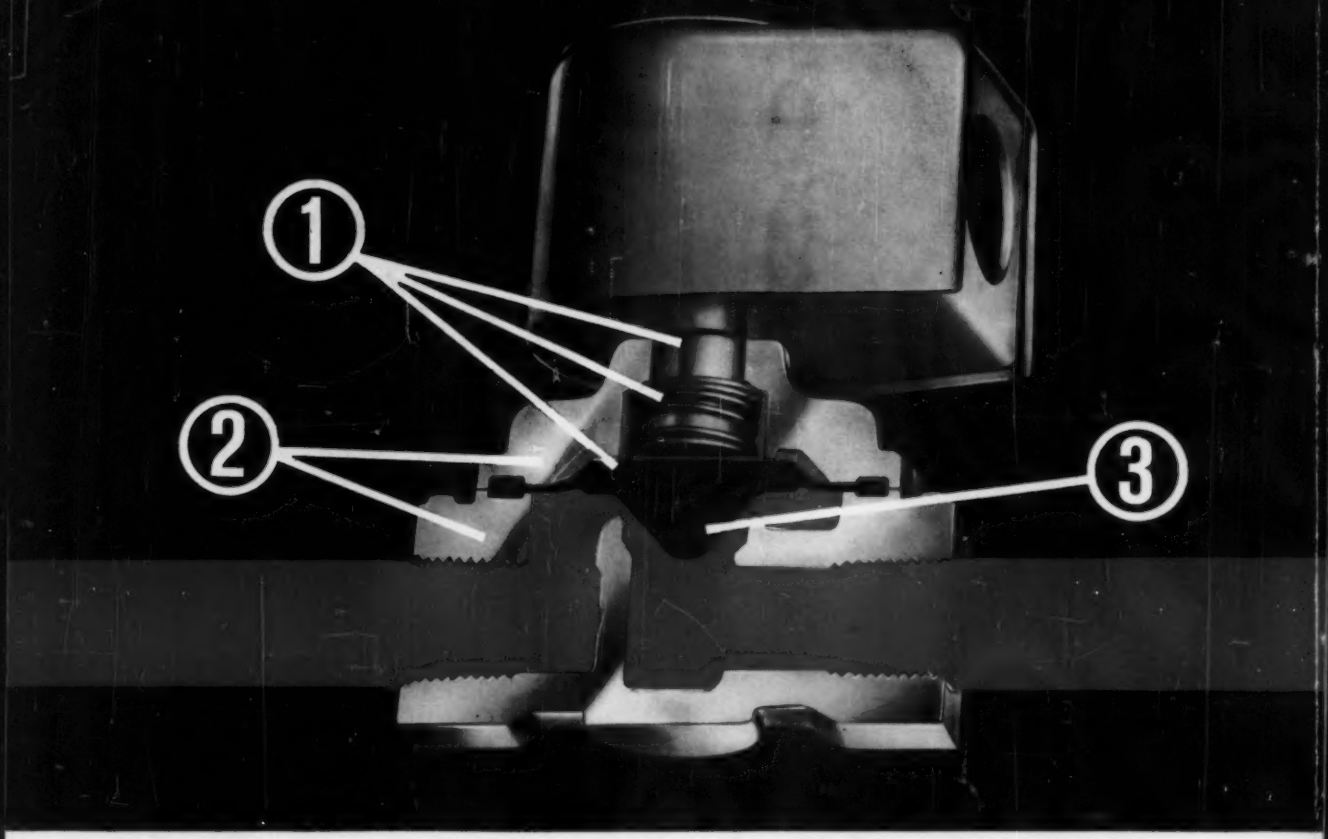
GRINDING CONTROL—Self-compensating Centerless Grinder Control assures production of consistently uniform parts. Corrects grinder automatically in increments of .000025". Can be used for rough or finish operations. Extreme reliability and 100% repeatability.

HARDNESS TESTING—Automatic High-Speed Hardness Testing Machine inspects up to 2500 parts per hour with laboratory accuracy. RCA Superficial type Hardness Tester capable of inspecting up to 6,000 parts per hour is also available.



SIMPLICITY, RUGGEDNESS, TIGHT SEATING,



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ASCO general purpose packless valves are now provided in a full ⅜" to 3" range . . . handle pressures up to 350 p.s.i. . . . ½" and ¾" sizes available to 1500 p.s.i. . . . provide dependable flow control for air, gas, water, light oil and other non-corrosive fluids.

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1. **Simplicity** in construction: Only three operational parts: all stainless steel core, stainless steel spring. Hycar diaphragm, ⅜"-¾" sizes . . . bronze piston ¾"-3" sizes.
2. **Ruggedness:** Forged brass bonnet and body insure freedom from porosity.
3. **Tight shut-off:** Assured by resilient disc construction.

Compactness: 2¾" face to face; 3¼" pipe center line to top of solenoid; 3-13/16" overall height. (Normally closed, ⅜" x ½" sizes.)

Mountable in any position: Normally open or normally closed.

Fast action: Rapid filling-venting operation permits cycling rate to 400 per minute.

All sizes have full area ports, continuous duty coils designed for low temperature rise and long life, and are available normally open or normally closed with standard, water tight or explosion proof solenoid.

Whatever the crucial factor in your flow-control application – reliability, compactness, high cycling rate – there is an ASCO valve that meets your need.

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